SILICON CHIP

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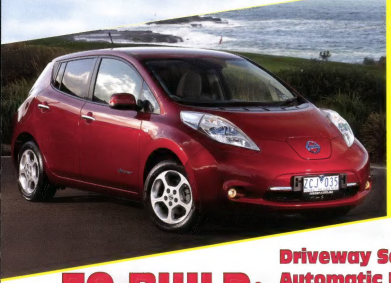

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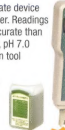

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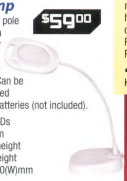

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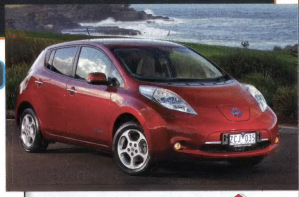

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Publisher's Letter

Australians' knowledge of science is abysmal

For a long time now, we have been very concerned about the standard of teaching science in Australia and indeed, the low priority it appears to get in Australian secondary schools. Never mind the fact that Australian scientists like Brian Schmidt, Peter Doherty and Elizabeth Blackburn have recently won Nobel prizes for their work because the average Australian's knowledge of science is abysmal. In fact, if you asked the average Australian who these three scientific giants were, you would get a blank stare.

Sure, Australians love technology but very few have more than a superficial understanding of how it works. I was reminded of this recently when I watched a program on Stephen Fry's "100 Greatest Gadgets". Stephen Fry is no mean intellect himself but he still managed to trivialise the whole 2-part program and ended by naming the top "gadget" as the cigarette lighter! As he waded through the list, which seemed to have no increasing significance in scientific development, it occurred to me that neither he or most of the (likely limited) audience would have much ability to explain how any of them worked. How depressing!

But even more depressing is an article in *The Australian* newspaper on Tuesday, July 10th, on the new syllabus for physics, chemistry and biology for Years 11 and 12. Just read this quote from a statement introducing the syllabus:

"Science is a social and cultural activity through which explanations of natural phenomena are generated."

"Explanations of natural phenomena may be viewed as mental constructions based on personal experiences and result from a range of activities including observation, experimentation, imagination and discussion.

"Accepted scientific concepts, theories and models may be viewed as shared understandings that the scientific community perceive as viable in light of current available evidence."

Well, what a lot of meaningless, mealy-mouthed, politically correct drivel! In fact, it is just drivel. If that is how the syllabus authors regard science, then heaven help us. They clearly have no concept of what science is about or how it has developed over centuries. It is just this sort of thinking which is so prevalent in the so-called consensus on global warming, being that the "science is settled". It isn't and it probably never will be.

Thankfully, this vacuous view of science outlined by the Queensland Studies Authority was rubbished by the Australian Council of Deans of Science, representing the heads of science faculties in Australia's universities. Their language was not as strong as mine but at least it was along the same lines. We need a much more realistic view of the importance of science and its teaching.

My attitude to science is this: if you don't understand basic science, you cannot have any understanding of the environment around you. If you do not understand science, you cannot understand how any of today's technology works. If you don't understand science, you are utterly reliant on other more educated individuals to ensure your survival in the modern world.

If you don't understand basic science, you might just as well be living in the middle ages! But with the wonderful resources of the internet, not understanding basic science is not a matter of lack of intelligence – it is laziness.

Leo Simpson

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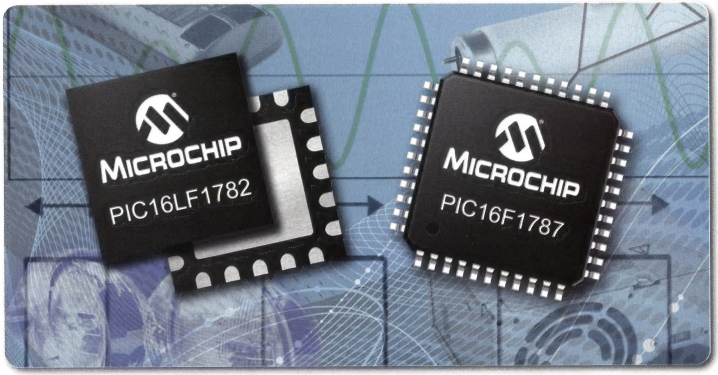

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MAILBAG

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Comments on Publisher's Letter in the June issue

With respect to the Publisher's Letter in the June 2012 issue, I totally agree with his comments about poor rear vision in many of today's cars. It's worse than some cars back in the 1950s. Best vision we have ever had was a 1982 Toyota Corona and a 1983 Fairlane. You could see everything.

I was intrigued with the letter from Hans Moll entitled "LED replacement lamps work well" and his hassles with interference from dimmer-controlled lights. He bemoaned the fact that "No one has any suggestions as to how to overcome this interference".

What? No-one? This problem is as old as Methuselah and its due largely to the minimalist design of the dimmers. As I recall, *Electronics Australia* did a design some time back to correct this and many years ago when I was building Triac-controlled speed controllers for drills, the addition of a choke and some capacitors cured the problem. How about re-publishing the design for old-time's sake?

This brings me to a big whinge. We went through a period where the Government flogged us to death about C-Ticks etc so that we would have equipment that would be certified not to emit any EMI. I have DVD and CD players which emit so much EMI that I can not use an AM tuner in the same cabinet when they are on but not fully in use. They have a C-Tick though! As usual, it's another useless Government initiative.

In the "Ask SILICON CHIP" pages of the same issue, you had a brilliant response to R. P. Horley, in the UK, about his "improvements" to the Ultra-LD Mk.2 Amplifier. Apart from the issues you referred to, what about the speakers in use to audition the changes, how good are his ears, etc, etc? Tests such as he seems to have done cannot detect the change he is talking about; it is humanly impossible.

Keep up the good work.

Ranald Grant,
Bellbowrie, Qld.

Soldering SMDs is straightforward

The Universal PIC/AVR Programming Adaptor Board featured in the May 2012 issue is the first major SMD based project I have tackled and I have now assembled all of the SMDs on the top side of the board and found that with patience and the described SILICON CHIP technique, I am more than happy with the soldering outcome.

I would like to pass onto other readers that this project is not as daunting as it first may seem. Where in the past I have tended to shy away from SMD projects, I now look forward to future offerings from SILICON CHIP.

Warwick Guild,
Dunedin, NZ.

Cameras will never replace reversing mirrors

In answer to the Publisher's Letter in the June issue and his suggestion that video cameras could replace rear view mirrors, this is why they should be retained. First is safety. Mirrors are unaffected by power failures. Mirrors have an MTBF of decades. A full set of mirrors is effectively a "dual redundant" system.

Mirrors encourage driving skills, not technological laziness. I prefer to drive manuals for the same reason. Finally, mirrors will always be cheaper than a dual-redundant triple camera and screen system.

Fabian Stretton,
Surrey Hills, Vic.

Comment: many cars now on sale come with a video screen and often a

School crossing lights should be much cheaper

I was the original researcher who assessed the initial school speed zone signs for the NSW Roads & Traffic Authority. Together with my colleague, Chris Cunningham, we carried out what proved (when we went to publish) to be the largest study in the English speaking literature. We thought it was a pilot. The RTA never found out we were a geographer and a town planner. I could talk the engineer speak!

Our findings were that at 50% of the sites studied we observed a statistically significant reduction in speed during the time of the signs' operation. In 50% of those cases, the reduction was 10km/h or more. So, they work.

We examined the semiotic literature and formed the view these were seriously bad signs. We recommended flashing lights, with the signs simply reading "40km/h when flashing".

My background (way back when) is as an appliance repair technician. I built a "proof of concept" model using the solar cell from my electric fence (I lived in the country) with a small sealed lead acid battery and an on/off switch operated by a modified remote control garage door opener.

The concept was simple: kids around, they switch it on; no kids, switch it off.

I figured I could build prototypes for testing on-site for about $1200 installed (two per school of course) but no interest.

I commend Peter Olsen for "having a go" on this. Having had the RTA for a client a couple of times now I know how he feels. Let me tell you about a road connection to a park we had trouble getting when I worked for a council. Wal Murray (then Minister for Roads) fixed that one in about 30 minutes.

I feel intensely frustrated that lives have been lost because we could not take the step of cheap, effective signs.

Angus Witherby,
Mordialloc, Vic.

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Mailbag: continued

School flashing lights: the simple English approach

Following the article on Peter Olsen and his Flashing School Lights in the July 2012 issue, I keep seeing school lights everywhere I drive now! I thought you may be interested in the lights and prices most commonly used in the UK.

The quote is for "one off", the new LED ones, but many schools still use traditional bulbs, turned on manually by magnet (off/on timer) and still available new for the princely sum of £126 (AUD200) each. Have a look at: **http://www.simmonsigns.co.uk/School-Crossing-Patrol-Signals.htm**

They are normally mounted vertically on the pole below the sign (I guess you know why) because (1) they are then at a better height (driver head height) and (2) vertically on the pole means they are easily rotated to point directly at the driver.

Clive Seager, Technical Director, Revolution Education Ltd, Bath, UK.

camera. Adding a few more could well be cheaper than external motor-driven rear view mirrors, particularly those that fold into the side of the vehicle.

Big organisations produce expensive solutions

With respect to the RTA and its expensive flashing lights, I've worked in big organisations. Over and over I saw that phenomenon you describe where the RTA insisted on installing flashing lights that cost $58,000 rather than Peter Olsen's ones that cost $1400. There'd have to be a committee of all the "stakeholders" and endless meetings where everyone around the table would demand some feature relating to their area of responsibility and none would concede it wasn't vitally important. And no-one around the table considered the cost. That was someone else's problem.

Everywhere you look in the technology area you see there is one product targeted at consumers that just gets on and does the job the customer wants, and another for "enterprise" customers that costs a number of times as much that is loaded up with an endless list of rarely used and/or largely useless features that end up making it harder to use and less reliable.

That's what scares me about the NBN. I look at the unit that is being installed at each premises and it was obviously designed by exactly that sort of process. No-one at the table considered the cost to be their problem and no-one spoke for the customer and what they want.

Halogen incandescent lamps are available

On page 8 of June 2012 "SILICON CHIP" there is a letter referring to the proposal by the Howard government in 2007 to ban incandescent light bulbs. As far as I know, incandescent light bulbs have not been totally banned in Australia or anywhere else. Have a look in your local hardware store.

What has changed is that incandescent bulbs with an efficiency level of less than 15 lumens per watt (lumens/watt) are rapidly being phased out. Lumens are a measure of light output and watts are a measure of energy input. For comparison, a compact fluorescent produces about 50-75 lumens/watt and the latest LED bulbs up to 100 lumens/watt. A 100% efficient light bulb would produce 683 lumens/watt. So the 15 lumens/watt limit can be interpreted as meaning all light bulbs must have an efficiency of at least 2.2%.

The 15 lumens/watt requirement has led to restrictions on the sale of most downlights as well as the traditional tungsten incandescent bulbs. These restrictions do not apply to specialist lights where there is no alternative, for example oven lights.

Halogen-filled incandescent bulbs are available for those who wish to continue to use an incandescent bulb. The following site has details of available incandescent bulbs within Australia: **http://reg.energyrating.gov.au/comparator/product_types/40/search/comprehensive/?wrapper_search=&lamp_type**

The reason why incandescent bulbs containing a halogen gas are more efficient is interesting. Like the traditional light bulb, a halogen lamp is made of a tungsten filament encased inside a transparent envelope. In a traditional element, the tungsten gradually evaporates and deposits on the glass. Eventually, the filament breaks. But by adding a small amount of a halogen gas this "evaporation" can be reversed.

Halogens combine with tungsten if the temperature is sufficiently high. By including a halogen gas, for example bromine, the generated tungsten vapour is recycled back to the filament rather than simply being deposited on the inner walls of the envelope. Almost total tungsten recycling occurs if the glass envelope can be kept at 250°C but this requires special quartz glass and care with bulb handling. Domestic replacement halogen bulbs run with slightly lower temperatures and so can be handled like traditional light bulbs.

An incandescent bulb filament is by far the hottest object we are ever likely to experience. A halogen light bulb filament runs at around 3100K, over half the temperature of the Sun's surface. This is the reason halogen bulbs give a good white light that is not too far from the natural light emitted from the 5500K surface of the Sun. Traditional bulbs are slightly cooler, at around 2800K. For temperature comparison, steel melts at about 1800K, titanium at 2000K.

In summary, incandescent bulbs are still available. While government regulation may be hastening the replacement of incandescent bulbs, a greater threat to their long term survival comes from technological change, in particular the newer LED lights.

John Cameron,
Roseville, NSW.

Comment: it seems that the widespread availability of halogen lamps in standard bulb sizes is a recent development because incandescent lamps largely disappeared from hardware shelves in the years after 2007. In any case, the halogens are much more expensive than the standard incandescent lamps they have replaced.

It is a phenomenon that becomes worse the more people specialise, as generally happens in our increasingly expert-driven society but especially in organisations that are big enough that responsibility for both success and failure is divided up. The more people have jobs, salaries, positions and power based on a small area of expertise, the most convinced they become that that area is more important than everyone else thinks it is. They lose the ability to get the big picture in perspective.

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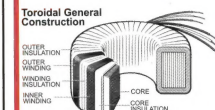

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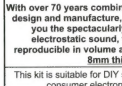

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Mailbag: continued

Applicable standards for program loudness measurement

In recent months, your Mailbag has had several letters which have commented on the problems of loudness and especially level differences between broadcast adverts and program content or between different channels. None of your correspondents seem to be aware that in the past couple of years, this problem has been given considerable attention from various related professional standards committees. In particular, the ITU (International Telecommunication Union) and the EBU (European Broadcasting Union) have done a lot of work.

Realistic and practical standards have now been defined for measuring perceived program loudness, and procedures for handling materials from different sources with and without loudness metadata. The ITU got the ball rolling a few years back with exhaustive listening tests and refinement of measurement algorithms, to produce the ITU BS.1770 standard for loudness metering – see **http://www.itu.int/dms_pubrec/itu-r/rec/bs/R-REC-BS.1770-2-201103-I!!PDF-E.pdf**

The EBU weighed in with recommendations on the implementation of systems to use this. A short overview and links to a bunch of relevant documents is at: **http://tech.ebu.ch/loudness**

The BWF (Broadcast Wave File) standard has also been updated to provide for embedding loudness parameters in a soundfile's header. This enables processing systems to read the file header and determine what levelling and/or compression is required for that item. I believe similar work is also being done for audio embedded in video and streaming formats.

Practical loudness meters are now available in either hardware-based devices or software plug-ins from various vendors.

Recent industry conferences have featured workshops aimed at educating the engineers and management at Australian broadcasters to work through the implementation of these standards.

How well and how soon these recommendations are implemented will depend on the particular organisations. Implementing the standards generally requires some changes to hardware/software and training staff, so that can all take time, unless the organisation has a strong commitment to the process.

Noel Bachelor,
Castle Hill, NSW.

It is why big organisations, despite their supposed "economies of scale", almost invariably produce products that cost more than small ones do.

Gordon Drennan,
Burton, SA.

Urns and oven should be better insulated

I have just read about the effort you put into reducing the amount of power that your urn uses (Circuit Notebook, page 60, July 2012) and it reminded me of a bench-top oven we purchased, because the big glass oven in the kitchen was too expensive to use for just the two of us. My wife tried to bake a cake in it but without much success and she asked me to see if there was anything wrong with it.

I inserted a thermometer into the oven to see if it actually reached the temperature she required. Well, it fell far short. I left it on for quite a while and the elements (one top & one bottom) stayed red all the time. A quick check with an ammeter showed that they were pulling the rated current. That meant the wattage of these elements was quite large enough for the job, so what was wrong?

I just happened to touch the outer case and got a good burn and I knew what was going on. These ovens aren't made like the old ones which were fully insulated; they just wrap a metal case around the sides and over the top. The back and bottom are just the walls of the oven itself. I happened to have some high-temperature insulation in

the shed so I enclosed the oven in this, making a metal piece to cover the back. I left the bottom as it was. I also fitted a proper thermostat out of an old oven so as to give a more reliable temperature control.

The oven is now a much-used item and does a really good job. Not only that, you can't get burned by the case any more and as the elements cycle on and off it must be using less power. Another thing is that in the warm weather it must mean that the air-conditioner has just that little bit less to do.

So if you can get a fully-insulated urn, you will not only save on the power that the urn uses but also on air-conditioning costs in the hot weather. What I would like to know is why they stopped insulating things that get hot?

Ron Groves,
Cooloola Cove, Qld.

More on home solar power system

This is a follow-up letter about my experiences with my home solar power system, as detailed in the Mail-bag pages of the September 2011 issue. A couple of weeks ago the installing electrician came to visit me with a new DC isolator switch. He said that the Electrical Inspector from the Queensland Dept. of Justice had contacted him to say that the previous unit was now the subject of a recall.

So he had procured a replacement – this time another Chinese product that he said cost him only $40. It is branded Clipso, a spoof of our famous Clipsal brand.

Low-cost, effective lens for the LED Dazzler

I built the LED Dazzler (SILICON CHIP, February 2011) when it first came out and although it was extremely bright the light output wasn't really usable. I recently stumbled upon some lenses for the STAR P7 LEDs on eBay at two for $6.29. I bought two lots and I fitted them to two of the LEDs.

I had to do a small amount of filing to get the lens to sit flush onto the metal PCB but it only took minutes. Now I have really usable light output. I tried to take some photos but they didn't do the light output justice. They can illuminate my shed which is about 60 metres from my house and I would not hesitate (if I had to) to drive down the road using only these LEDs. These are only cheap plastic lens and I wonder what quality lenses would be like.

Tony Brazzale,
Lakes Entrance, Vic.

What's concerning to me is that even though I have made a formal complaint to those inspectors, including a written statement, I have never received any written communications from them and it is over a year since I made my first complaint. Even more disappointing is that the installer told me that he has overcome all of the problems that I experienced in subsequent installations by doing the following:
(1) Supplies and installs a German-made inverter that has an internal iso-

Mailbag: continued

Highly priced power fuses cannot improve sound quality

I saw this advert on eBay recently and thought I'd send it to you so you can publicly "rip into" this mob (if you want to): **http://www.ebay.com/itm/ws/eBayISAPI.dll?ViewItem&item=150695403285&ssPageName=ADME:B:EF:US:1123**

It is incredible that people can get away with such fanciful advertising about something that has absolutely no chance of providing the performance enhancements claimed.

Peter Allen,
Tura Beach, NSW.

Comment: we have no doubt that there are enough gullible people "out there" to make such outrageous advertising very worthwhile for the promoter. Such are the consequences when most of the population have little understanding of even the most basic technology.

lation transformer, so now he doesn't bother to put an earth wire to the solar panels. He said this inverter cost about $800. He must think that earth wire is prohibitively expensive.

(2. He now splits the solar array into two runs so that he can use a lower power DC isolator switch. This presents another problem that seems to be of no concern to him. If the customer wants to generate power at the beginning and end of the day, it is necessary to have as many panels in series as possible to create a voltage higher than that required to start the inverter and to pump power into the grid because that is what we are being paid for.

These two decisions on the part of the installer highlight the absence of a Certified Designer in the supplying company. But according to the Clean Energy Council, each supplier must have one of those to ensure correct design.

Anyway, it is all a bit academic now, because the new Queensland Premier has decreed that all new contracts for the supply of renewable energy into the grid will be at 8c/kWh instead of the current 44c/kWh.

Chaim Lee,
Toowoomba Qld.

Inverter generators confuse appliance with switchmode supplies

In reply to Ron Goodwin's letter about mains AC waveform distortion in the July 2012 issue (page 4), I have a possible explanation on why some portable generators have trouble with appliances with switchmode power supplies.

Ron mentions cheap generators having problems with "filthy output" but I believe this is a "red herring". The real culprits, and he notes this implicitly, are the rather expensive generators (non-inverting and probably inverting as well) with high-tech controls and AVRs.

Some people might pay more to have high-tech equipment just for its own sake but most of us pay extra for what the high-tech gear can do, not for what it is. As such, these types of generators are claimed and expected to be more efficient (cheaper to run), more green (save the environment), more convenient (we are a lazy lot) and less intrusive (keep the noise and the weight down) than the run-of-the-mill type.

Therefore, if there is no load on the generator it can sense this and stop producing a nominal voltage waveform. This can, depending on the design, reduce the off-load running costs for fuel and maintenance as well as lowering ambient noise levels. In a lot of normal usage, the generator is actually off-load for a considerable percentage of its working cycle, so significant savings can be made over a generator with a more conventional AVR.

Of course, the generator will excite its fields slightly and regularly during this off-load time and sense the current draw to determine if a new load has been added. The problem is that the high-tech appliance with electronic control circuits and/or switchmode power supplies requires close to the

full nominal voltage before allowing the appliance to be fully powered up and functional. Thus we have a classic "chicken or egg" situation.

The generator won't supply nominal power until a load is present and the load won't become present until the nominal power supply is available. The simplest and best available workaround is to introduce a plain, low-tech resistive or inductive load that alleviates this paradox.

I must state this is only a theory as I don't have access to the intricate details of modern high-tech portable generators or modern high-tech appliances and how they may interact with each other. But casual observations of cause and effect seem to agree with my theory.

Trevor Krause,
Gympie, Qld.

Fitting an oxygen sensor to a Land Rover

In the "Ask Silicon Chip" pages of the June 2012 issue there was a query from M. M. regarding fitting heated oxygen sensors to an older model Land Rover Discovery. Although the writer does not indicate which model he has, I assume that it is probably of similar vintage to my 1995 Discovery. If so, then M. M. should be aware of the following points:

The Lucas 14 CUX ECU that is most probably fitted to his vehicle can accept oxygen sensor inputs and continued to be used in later models with oxygen sensors and catalytic converters. Apart from any ECU socket shortcomings, the only change required to the ECU to enable oxygen sensor inputs is to change the value of the "sense" resistor which selects an alternate operating program that looks for oxygen sensor inputs.

This ECU was designed to operate with Titania oxygen sensors which have a sharp resistance change at stoichiometric operation, rather than the sharp voltage change of the much more common Zirconia type sensor. The two are not interchangeable and the voltage output of the wideband oxygen sensor would also be unsuitable as an input for an ECU designed for Titania sensors.

The heater incorporated with the Titania sensors specified for the Discovery does not have any special control requirements and can simply be connected to the appropriate terminals in the wiring loom. The addition of Titania oxygen sensors to a pre-catalytic converter on the Discovery is certainly possible and can significantly improve fuel economy but it is not for the faint-hearted.

An internet search on the Lucas 14CUX ECU should provide M. M. with some additional background.

Don Brown,
Beachmere, Qld.

Good home wanted for EA magazines

Just a note to let your readers know that I am about to finally clear my collection of *Electronics Australia* magazines. I realise that they are probably of very little use to anybody else but I would rather give them to a good home than just throw them away.

They are free to anyone that would like them but they will need to be picked up as they are quite heavy and would be very expensive to transport. I have all copies from May 1967 to July 1990 inclusive.

Steve Tobin,
6 Endeavour Ave,
Orange, NSW.
Phone 0429 339 867. SC

Power filter can reduce clock gain

I noted that there was discussion on "Clock Radios Gaining Time" in the Mailbag pages of the July 2012 issue. I have recently had solar power installed and also noted that a previously accurate clock radio was gaining six minutes each day.

As a starting point, to eliminate this time gain, I installed a line filter & conditioner I had previously constructed. Initial results indicate that there is now only a one minute gain per day. It's not a total fix but this result may give a clue as to what the interference is.

Gordon Charlton,
Sunbury, Vic.

Nissan's new LEAF

On June 15, the much-anticipated Nissan LEAF 100% electric vehicle went on sale in Australia. Not co-incidentally, this was also the day it was introduced to the media – including SILICON CHIP. We had a good look at the LEAF and took it for a reasonable (if all-too-short) drive. Were we a little impressed? No way! We were *very* impressed!

Review by Ross Tester

We're going to resist the puns like "turning over a new leaf" and so on – we'll leave those to other media. We were more interested in the technology behind this vehicle and just how it can fit in to our readers' lives.

According to Nissan Australia's Managing Director, the LEAF will be slow to take off (they're only expecting to sell "hundreds of units" in the first year, compared to thousands of their conventionally-powered models) but eventually it, or its successors, will become the mainstream motor vehicle for many, perhaps even most, *urban* Australians.

This forecast mirrors the LEAF experience in the US, where it has been on sale since late 2010. First month sales were just 19, with 9674 sold in 2011 and 2613 sold between January and May 2012.

We're talking years away of course. Like any new technology, there will be the "early adopters" but convincing the average Australian driver to accept electric vehicles is not going to be an easy sell. Especially as they are significantly more expensive than petrol or Diesel-powered counterparts.

But first, we're going to nip some anticipated criticism in the bud.

When we reviewed the Toyota Prius/Honda Insight hybrids and more importantly the Mitsubishi i-MIEV (December 2001 and February 2011 respectively) we received some rather scathing correspondence, not criticising our reviews as much as the technology itself.

There were two sides to that cricitism and by extension, we believe some readers will apply them to the LEAF as well.

Green machine?

First was the condemnation of the electric vehicle's "green" credentials but most strident was the criticism

- 100% EV

zero emission

of their range. "Who would want a vehicle which only travelled 100+ kilometres before needing recharging and even then had trouble keeping up with traffic on a freeway," they asked.

Let's answer that question first: Considerable research by various bodies around the world has shown that the vast majority – 80% in fact – of urban commuters drive less than 100km each day. That includes Saturdays and Sundays, when they might be running the kids to sport, going on a picnic, to church, etc.

Indeed, Nissan's "actual use" figures from 7,500 LEAFs in use in the USA reveal the average vehicle drove 60km per day with the average trip 11km in length. (We'll look at just how Nissan gathered those figures shortly).

Therefore, contrary to the naysayers, electric vehicles are *very* well suited to the vast majority of urban commuters!

Nissan's Australia's CEO Bill Peffer put it best: "When you come home from work, you plug in your mobile phone to charge it overnight. Nissan LEAF owners will also plug in their electric car to charge it overnight . . ."

And don't worry about keeping up with the other traffic – with a top speed of 140km/h and great acceleration, you'd be passing most of it. Just watch out you don't get pinged for speeding!

Then comes the next (inevitable!) somewhat derisory question: "What happens when you want to go on holidays. You're going to need a very long extension cord, ha ha!"

Again, this demonstrates a total lack of understanding of typical Australians' changing holiday habits. These days, they're much more likely to fly to their destination and if needed, hire a car, 4WD, or whatever.

You'd hardly want to cram all the kids, luggage and so on into what amounts to a small car to travel from Melbourne or Sydney to the Gold Coast, petrol or electric powered.

If you really must drive distances, then an electric car is probably not for you (at least yet!).

As far as size goes, think Mazda 3 or Toyota Corolla and add a little.

Green power

Correspondents also challenged us on the green credentials of electric vehicles on a number of fronts: the energy required to produce the batteries, motor and so on (of course, no energy at all is required to produce an internal combustion engine) and again, more important to some, the greenhouse gases produced in making the electricity to charge the batteries.

To be brutally frank, we dismiss these criticisms out of hand. Despite our current government's insistence that we humans are nasty people for daring to use coal-dependent electricity, we all know that electricity must be produced this way for the foreseeable future (we're talking decades here at least) for the vast majority of "base load" power.

Turning back to charging electric vehicles, it is antici-

Inside the LEAF it looks much like any modern 5-door hatch . . . until you start looking a bit closer. Things like that "gearstick", for example. And then if you look at the instrument panel and centre console display, you really start to see some differences!

A cut-away of the LEAF showing the charging ports (front) with the motor immediately behind, the under-floor batteries and the 3-phase controller immediately behind. On top is the solar panel which keeps the 12V system battery charged.

pated (as mentioned before) that the vast majority will be charged overnight, using predominantly off-peak power.

Incidentally, Nissan have gone out of their way to make the LEAF as environmentally friendly as possible, with recycled material used extensively in manufacture and the vast majority of the vehicle is itself recyclable.

OK, let's look at the LEAF

First of all, that name: it apparently stands for Leading, Environmentally friendly, Affordable, Family car (though you won't find that in Nissan literature).

It's not Nissan's first electric car – in fact, they're quick to point out that the company's electric vehicle pedigree goes right back to post-WWII Japan with its oil shortages.

In the intervening 65 years various electric vehicles have been made, including some concept cars which never saw the production line.

Nissan claim the LEAF is the world's first *purpose-built*, mass-produced all-electric car (one wonders where they place the Mitsubishi i-Miev which predates the leaf by many months). It's 100% electric, unlike several hybrids (electric cars with petrol engines also supplying power) and others like the soon-to-be-released Holden (Chevrolet) VOLT – an electric car with back-up petrol generator.

As such it can boast not low emissions, but ZERO emissions. There is no tailpipe/muffler because there is no engine exhaust.

It's a five-door hatch, not too dissimilar to many other petrol hatchbacks on the road today. But there are also subtle (and not-so-subtle) differences. Again, Nissan point out that the LEAF was designed "from the ground up" to be an electric car, not an adaptation of an existing petrol/Diesel-powered vehicle.

It's claimed to have room for five people but in our test drives we sometimes had four adults in the car – and the fifth person would have had to be a leprechaun. It might just fit two adults and three kids, but you wouldn't want to drive for too long. Oh, you can't anyway!

There is no gearbox as you are used to. You simply have the choice of forward and reverse, selected by a computer mouse-inspired control knob.

There is also no ignition switch – as long as you have the RFID "key" in the car (eg, in your pocket) all you do is push the engine start button and the vehicle energises after a second or so with suitable chimes and so on. The engine doesn't exactly start – it's ready as soon as you apply the accelerator in the conventional manner.

And what acceleration! As you probably know, electric motors develop maximum torque at virtually zero RPM. So if you're looking for get-up-and-go, the LEAF certainly gets-up-and-goes. Performance has been equated with that of a typical 3-litre V6 petrol-engined car.

In the drive, which took me from the launch at Little Bay (SE suburbs) up towards Sydney city and back again, I had no trouble at all in keeping up with other traffic – and could easily overtake when I wanted to.

While on the subject of the drive, I have to admit that I found the lack of engine noise somewhat disconcerting for the first few minutes but then it was ignored. I noticed it again (or lack of it!) when stopped at traffic lights but I'd suggest this problem is one I'd easily get used to.

Wind noise was perhaps more noticeable than in most cars but this was arguably because there was less engine noise. But it's not something I found annoying or even intrusive.

An aside: the Nissan technical guru who accompanied me on the drive explained that the headlights were especially sited to break the laminar wind-flow so that it went around the external rear-vision mirrors, thus reducing their noise!

While a small-ish car, it has a healthy 2700mm wheelbase so it certainly doesn't jump around like a jackrabbit.

Overall length is 4445mm, width 1770mm while the height is a quite low 1550mm. Nissan explained the design has been optimised for low drag coefficient in order to get

the maximum range from each charge.

As such, the front is quite low and ground clearance also relative low at 160mm. It's heavy for a small car at over 1500kg, explained to a large extent by the weight of the batteries and motor. Maximum payload is just on 400kg.

Batteries and motor

Nissan and its partners have spent most of the development time of the LEAF in researching and producing batteries. The LEAF is a far cry from their post-war "Tama" electric car – it used lead-acid batteries, had a range of 65km and a top speed of 35km/h.

By contrast, the LEAF uses a purpose-built 24kWh Li-ion battery comprising 48 modules, each of four cells. Each person I asked at the LEAF launch gave me a different battery voltage and no-one could tell me how the cells were connected but I'm guessing that they are arranged as two paralleled banks of 24 cells, giving the total battery voltage about 360V (ie, 4 x 24 x 3.75V = 360V).

In contrast to most other electric or hybrid vehicles, which often have the batteries in the boot space or under the rear seat, because the LEAF was an all-new vehicle Nissan had the luxury of placing the batteries wherever was best suited. This turned out to be underneath the floor, right in the middle of the vehicle. It was made even easier with no prop shaft or exhaust pipe to worry about.

Battery life

There's been a lot of (mis)information on many websites and even some media about battery life of electric vehicles. "Expect to replace the batteries in 3-5 years" was a comment I read more than once.

When queried, Nissan maintain they expect the LEAF batteries to have a life of at least 8-10 years and were anticipating even more – perhaps 15 or so.

In fact, the LEAF in the USA has an eight-year/160,000km warranty on the batteries and they wouldn't do that if they weren't confident of their life predictions. I'm presuming it will have the same warranty here.

Battery life depends on how you drive and most importantly, how you charge. If you continually rely on the fast chargers that are (very) slowly springing up around major cities, your battery life could be significantly curtailed.

But if you use the relatively slow charge from a 230V/15A outlet, drive smoothly and not discharge the batteries too far before charging, then you could easily meet or exceed Nissan's expectations.

If and when required, a battery changeover would set you back somewhere around $10,000 at current rates but given the state of battery development and increasing volumes of production, could be significantly lower in ten years or so.

Before concluding the discussion on the batteries, it's interesting to note that the LEAF also has a 12V lead-acid battery in the engine bay which supplies power to all the low-voltage vehicle peripherals.

We have to assume that it is also kept charged via the main HV battery but the Australian version of the LEAF also has an integral solar panel in the rear spoiler which also charges the LV battery when the vehicle is parked outside in daylight.

The motor

A 3-phase 80kW synchronous AC electric motor provides front-wheel-only propulsion with 280Nm of torque. This is powered from the battery bank by a DC/AC inverter with computer control. The motor is not too dissimilar in size to a 4-cylinder petrol engine (see photo) and occupies the majority of the engine bay.

The motor spins out to a maximum 10,390 RPM with a single-speed gearbox ratio of 7.9377:1

Charging

Two charging points are provided on the front of the LEAF. One is for a standard 230VAC 15A outlet (which results in a 14 hour full charge) and the other for a 400V "fast charge" (four hours).

The car itself has both a 3.3kW normal and 50kW fast charger on board. The fast charger will charge the battery to 80% full within 30 minutes.

At the time of writing, there were 16 fast-charge points around Sydney (and the car will tell you where they are).

Normally there is a small charge (I believe between $2 and $10) to "fill" the car – a lot less than the $50-$70+ it now takes to fill an average small car petrol tank.

However, in the US, where the LEAF (and other electric cars) have been available now for over a year, many shopping centres and other venues have been putting in fast-charge points and/or standard power outlets (with appropriate electric-vehicle-only spaces) which are free – they figure the longer they can keep you there the more you'll spend inside!

THE CURRENT STATE OF EV PLAY

True EV (ie, 100% electric vehicle)

Mitsubishi iMiev – $48,800	Available in Australia now (limited dealerships)
Nissan LEAF – $51,500	Available in Australia now (limited dealerships)
Tesla – up to $205,000+	Various models available USA, Japan, Europe now. Limited availability in Australia
Renault Fluence ZE – $TBA	To be launched late this year (has swappable battery).
Ford Focus EV – $TBA	Limited availability in USA now, Australia "probably 2014"

Hybrids (ie, combined electric/petrol)

Toyota Prius –	3rd version now available in Aust. EV version now available in the US.
Toyota Camry –	Available in Australia now
Lexus Hybrid –	Available in Australia now
Honda (Insight, Civic, CR-Z) –	Available in Australia now
Holden Volt (HEV) –	Available in USA (Chevrolet Volt) since Dec 2010; Australia scheduled release Oct/Nov 2012

You can get a fast charger for your home – estimated price including installation would be around $2200 or so but I understand 3-phase power is required. If you need a 15A outlet and dedicated circuit installed, that would probably cost you about $250.

According to Origin Energy, the NSW electricity supplier whom Nissan have teamed with for LEAF energy supply, many businesses have, or are considering converting their local fleets to EV and are installing charging points for employees to use (again, free of charge).

The LEAF also features "electrically-driven intelligent braking" which is known to you and I as regenerative braking. Travelling downhill, energy is recovered from the engine to recharge the batteries. It's progressive – it wasn't easy to tell when regenerative braking kicked in nor, when I applied the footbrake, when it changed from regenerative to power-assisted mechanical.

Up to 80% of the energy of braking, normally lost as heat, is recovered.

LEAF - ZE0 – Specifications

Elec. Motor type	3-phase AC synchronous
Max. engine power	80kW / 2730-9800 RPM (min)
Max. torque	280Nm / 0-2730 RPM
Max RPM	10,390
Battery Type	Laminated lithium ion
Battery Voltage	360V
Battery Capacity	24kWh
Number of cells	192
On-board chargers	3.3kW and 50kW
Gearbox	Single Speed Gear Reduction
Final drive ratio	7.9377
Driven wheels	Front
Suspension front	Independent Macpherson strut
rear	Torsion beam axle
Steering	Electric power assisted
Braking system	Regenerative - FR Ventilated Disc
Kerb weight min./max	1525/1567kg
Gross vehicle Weight	1965kg
Maximum payload	395kg
Maximum axle load FR	1020kg
Maximum axle load RR	995kg
Overall length	4445mm
Overall width	1770mm
Overall height	1550mm
Wheelbase	2700mm
Track front	1535mm
Track rear	1535mm
Electricity consumption	173Wh/km
Range	175km
Maximum speed	145km/h
Acceleration 0 - 100 km/h	11.9s

Electronic "smarts"

The LEAF is much more than a battery powering an electric motor to drive wheels. No-one at the launch could tell me how many CPUs there were in the car but my guess would be dozens – much more than in a conventional vehicle.

First of all, there is all the battery monitoring and range computing. It can not only tell you the state of battery charge (a la the petrol fuel gauge) but from this, and the way you are driving, tell you how far you can go on that charge – and how much further you can go if you switch to the "eco" mode.

In this mode, acceleration is not quite as brisk (although plenty for 99% of circumstances). But if you happen to see an 18-wheeler barrelling through the intersection towards you, plant your foot and the mode changes back immediately.

Battery monitoring also controls how the car will drive. At normal levels, you get normal control but when it drops down to about 40%, the car starts progressively shutting down power hungry devices such as the air conditioner/heater. You also start to get warning messages via the console.

Ignore them and at a *much* lower charge (5%?) the car enters limp-home mode which (hopefully) will get you to a charging station (or home).

Keep driving, and the point is reached where the battery is regarded as flat. The car will keep going a short distance but at a dramatically reduced speed – it's intended to allow you to get off the road and perhaps around a corner before giving up the ghost completely.

If you're stupid enough to get this far (which is about the same as running out of petrol in the middle of the Harbour Bridge!) you're not going to be able to hitch a ride to a servo and fill up a can. You're going to need a tow truck unless you can find a 15A outlet very close and wait for a charge.

The amazing dash display

Integrated into the dash is a multi-function display which has many levels of menu selection to set, well, you name it!

Built into the rear spoiler is a solar panel which keeps the 12V aux battery charged when the car is parked in sunlight.

A cutaway diagram of the 360V battery pack especially developed for the LEAF. At right is the 80kW electric motor, also purpose-built.

I noted a speedo/odometer, battery power meter, battery temperature, remaining energy gauge, capacity level gauge, distance to empty display (2 modes), Eco indicator and even an outside temperature readout. (I'm sure there are more!).

It incorporates the 6-speaker entertainment system – again, all touch-controlled – along with the integrated GPS which allows the car to not only do all the things any "normal" GPS does but also uses the info to map range-before-recharge in both normal and eco mode.

It also displays the rear-view camera which is fitted with intuitive parking guides – lines which show you the vehicle's path (and obstacles) according to the direction of the steering wheel. Parking is therefore dead easy – not automatic, as in some cars these days (including some other Nissan models) but easy nevertheless.

And it also provides access to data to and from Nissan Carwings.

Nissan Carwings

The Nissan LEAF is fitted with what amounts to a mobile data phone, inaccessible to the owner (except for some incoming command "calls", as we shall see) but with its own SIM card and number. It cannot take or receive voice calls.

Every day, or every journey, this module "calls" the very secure Nissan International Data Centre in Japan and transmits data on the car's operation – the distance it has driven, vehicle parameters including state of charge, etc.

This information gives Nissan real-time data on every LEAF sold anywhere in the world – hence the ability of Nissan to be able to state, categorically, the average daily travelling of all LEAFs in the USA (see above).

But it also has the potential to alert Nissan to any vehicle problems long before the driver knows about them. Or it can, for example, suggest to a driver that their style of driving might result in shorter battery life!

This "service", arranged through Telstra, has a subscription which is free of charge to the owner for the first three years of ownership.

But there's much more this data module can do. For instance, it can enable the owner to remotely (via a mobile phone app) tell the vehicle to start charging when electricity tariffs are lowest (who wants to get out of a warm bed to turn the power switch on in the early morning?). This can also be programmed via the extensive menu on the dashboard LCD.

It can also be used to start the air conditioning at a certain time so the driver gets into a warm (or cool) car – this while still plugged in to the home charging circuit, so it doesn't use any vital battery charge. Again, you simply use the app on your mobile phone. Of course, at the same time, climate control is totally accessible from the centre console display.

About the only thing it doesn't do (which to me was a disappointment) was allow the ability to let the owner know where the car was – for instance, if it had been stolen.

With the fully integrated GPS and the ability to communicate via the phone network I thought this would be a natural – but the Nissan representative told me that they had argued very long and very hard with the Privacy Law authorities who continually kept putting roadblocks in the way.

Driving it

All I can say is that it was a real pleasure. Comfortable seats, smooth acceleration and braking (regenerative, of course!) with cruise control, Bluetooth phone interface if I wanted it and a driving position that allowed a superb all-round view.

As I mentioned earlier, there was no problem keeping up with city traffic on a variety of road types – about the only criticism I had here was trying to take in all the wizardry of the car while keeping an eye on the road!

It's comforting to know that it has achieved the highest level of car safety (five star, the first electric vehicle to do so) and has extensive safety measures built into the battery pack to isolate it in case of collision.

Would I buy one? If I had a lazy fifty grand or so lying around, I'd certainly consider it. Unfortunately, I don't! SC

Two charging ports are provided, one for 230V/15A home charging and the other for 400V fast charging

The latest thing in ~~UAVs~~ RPAs . . .

Remotely Piloted Aircraft (RPAs) are on the threshold of a major explosion in design, operation and areas of deployment. Leading the way in this revolution is a style of helicopter best known as a Quadcopter or Multi-rotor Copter.

By Bob Young

MULTI-ROTOR HELICOPTERS

In recent years, we've looked at several of the developments in UAVs (or now, officially called RPAs) and the technology used in these machines.

However we are now entering a new era in RPAs, driven by the fact that in the USA the Federal Aviation Authority (FAA) has been instructed by Congress to integrate RPAs into the US National Shared Airspace within 90 days for emergency services and by 2015 for civilian use. This is expected to result in an explosive growth in the use of RPAs.

Here in Australia, CASA, having originally led the world with an operational regulation (issued in 2002), is now working to bring an improved alignment between technology advances and aviation safety.

One outcome of the legislation (due early next year) is that commercial RPA "pilots" will need to be just that – licensed pilots. Some will only need an "RPL" ticket (Remotely Piloted Licence) but some classes of RPAs will need to be controlled by those with the equivalent of either private or commercial pilot's license.

Fortunately, we believe that the fun police won't be looking at small "hobby" quadcopters (which are referred to as SGMAs, or self-guided model aircraft).

Electric power

One of the machines featuring heavily in this new upsurge of interest in RPAs is the Electric Powered Multi-rotor Helicopter.

They range from fun "toys" (see the review of the Parrot elsewhere in this issue) through to large, complex machines intended for "serious" applications such as filming, surveying and military uses.

This type of vehicle is absolutely ideal for use in urban environments in that it is small, light, extremely manoeuverable and relatively quiet.

There is a wide variety of these machines ranging from three rotors through to eight or more rotors (even sixteen in the case of the man-carrying e-volo multi-copter, as we shall see). Some have four arms with eight motors mounted in pairs, one above the other. Others have eight arms fitted with a single motor. Each has advantages and disadvantages.

The media has recently discovered the advantages of these machines, leading to a class of journalism now entitled "Drone Journalism".

A camera-equipped multi-copter which fea-

RPAs? What happened to UAVs?

The ICAO (International Civil Aviation Organisation), the international aviation governing body, has recently "tidied up" their acronyms and have decided that the terms for UAV operations are to be re-designated Remotely Piloted Aircraft, or RPA. Thus we have RPL (Remote Pilot License), RPA (Remotely Piloted Aircraft) and so on. Over the years we have gone from RPV to UAV to UAS and now RPA! And don't forget that CASA have decreed that only commercial aircraft can be called "RPA" – hobbyist models are to be called self-guided model aircraft, or SGMAs!

tured in an incident at the Christmas Island Detention Centre last year caused quite a stir and has since brought to the fore all sorts of questions, not the least being privacy.

After taking photos of the Detention Centre, it crashed into the Indian Ocean, giving rise to rumours that it had been shot down.

The Author has since had it confirmed that it was not shot down but even so, Christmas Island Authorities were indeed quite upset about the whole incident, stating that "it instilled fear for all concerned below" with many of the detainees having first-hand experience of what RPAs are capable of doing from their years in Afghanistan.

However there are even more serious aspects of "Drone Journalism" to be considered. For example it is now quite feasible for a quadcopter fitted with a camera and real-time video downlink to fly up to a window and quite literally look through that window – or indeed, if the window is open, fly right through the window into the room.

If some of the over-achieving drone designers have their way, RPAs the size of cockroaches or household flies will be sitting on the wall or walking across the desk listening in to any conversation in the room.

The Civil Libertarians are going to go nuts over this stuff and it is here now. However, for military people they are a Godsend as they can completely remove any mystery from entering a room, peeking around a corner or looking over a hill without risking any soldier.

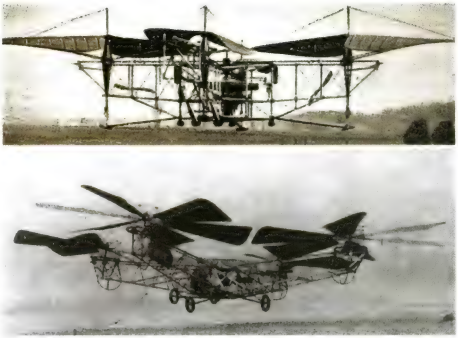
So what is a quadcopter and how does it work?

Origins of multi-rotor helicopters

The Frenchman, Etienne Oehmichen, experimented with full size manned rotorcraft designs in the 1920s and demonstrated the first successful helicopter on February 18, 1921.

Among the six designs he tried, his helicopter No.2 achieved considerable success. This machine had four rotors and eight propellers, all driven by a single engine.

The Oehmichen No.2 used a steel-tube frame, with two-bladed rotors at the ends of the four arms. The pitch of these blades could be varied by warping. Five of the propellers, spinning in the horizontal plane, stabilised the machine laterally. Another propeller was mounted at the nose for steering with the remaining pair of propellers being used for forward propulsion.



Two early rotor craft: the Oehmichen No.2 (top), said to be the first successful design and uderneath is the deBothezal machine developed for the United States Air Service. Both are from the early 1920s. (Photos courtesy Wikipedia).

The aircraft exhibited a considerable degree of stability and controllability for its time and was the first helicopter capable of reliably carrying a person. The No.2 made more than a thousand test flights during the middle 1920s.

By 1923 it was able to remain airborne for several minutes at a time, and on April 14, 1924 it established the first-ever FAI distance record for helicopters of 360m. Later, it completed the first 1km closed-circuit flight by a rotorcraft in 7 minutes and 40 seconds. (*Source: Wikipedia*)

Dr George de Bothezat and Ivan Jerome developed an aircraft for the United States Air Service with six bladed rotors at the end of an X-shaped structure. Two small propellers with variable pitch were used for thrust and yaw control. The vehicle used collective pitch control.

It made its first flight in October 1922. About 100 flights were made by the end of 1923. The highest it ever reached was about 5m. Although demonstrating feasibility, it was underpowered, unresponsive, mechanically complex and susceptible to reliability

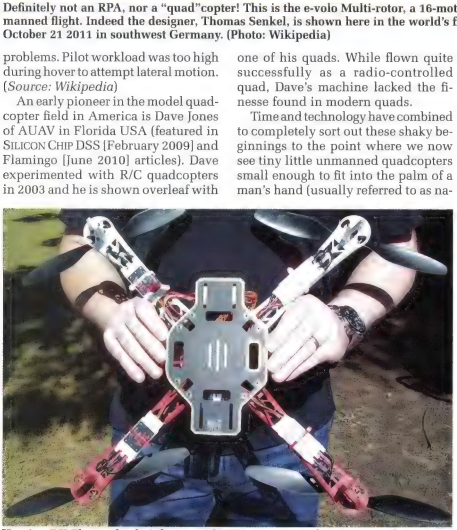
Dave Jones, an American pioneer in multi-rotor craft whom Silicon Chip readers may remember from earlier model aircraft and radio control articles.

Definitely not an RPA, nor a "quad"copter! This is the e-volo Multi-rotor, a 16-motor monster multi-rotor capable of manned flight. Indeed the designer, Thomas Senkel, is shown here in the world's first manned electric multi-rotor flight – October 21 2011 in southwest Germany. (Photo: Wikipedia)

problems. Pilot workload was too high during hover to attempt lateral motion. (*Source: Wikipedia*)

An early pioneer in the model quadcopter field in America is Dave Jones of AUAV in Florida USA (featured in SILICON CHIP DSS [February 2009] and Flamingo [June 2010] articles). Dave experimented with R/C quadcopters in 2003 and he is shown overleaf with one of his quads. While flown quite successfully as a radio-controlled quad, Dave's machine lacked the finesse found in modern quads.

Time and technology have combined to completely sort out these shaky beginnings to the point where we now see tiny little unmanned quadcopters small enough to fit into the palm of a man's hand (usually referred to as nanocopters), flying fully autonomously in formation using swarm technology. How times have changed.



Here's a DJI Flamewheel airframe with DJI 30A opto and DJI Nava stabilisation. The motors are 928kV DJI. This quadcopter has the familiar "X" pattern of rotors. The alternative is the "+" pattern which behaves quite differently. Both are explained in the text.

Manned multi-rotors

So what then of manned multi-rotors, have they been left behind?

By no means, as the photo above shows. German aircraft developer e-volo has developed a manned multi-rotor that it calls a multi-copter. While the company has previously demonstrated unmanned drones, on October 21st 2011 it accomplished what it claims is a world first – a manned electric multi-rotor flight.

It took place at an airstrip in southwest Germany and lasted one and a half minutes. Thomas Senkel, a physicist and designer/builder of the multi-copter, piloted the aircraft from a centre-mounted seat, using a hand-held wireless control unit. The flight consisted mainly of manoeuvering the multi-copter around within a fairly small area – no sense in getting cocky.

"The flight characteristics are good natured," Senkel said afterward. "Without any steering input it would just hover there on the spot."

According to e-volo, its multi-copter is simpler in construction and mechanics than a helicopter and safer - it can reportedly land even with up to four of its motors failed, and its propellers experience much less wear.

Onboard computers running custom firmware control the rotational speed of the propellers, dictating the attitude (horizontal orientation to the ground), altitude and direction of travel of the aircraft. Once again potential flight times are limited and range from 10 to 30 minutes, depending upon battery capacity and payload. As in most aircraft, payload and endurance fight with each other for supremacy with the mission requirements deciding the final outcome: long endurance, small payload; high payload, short endurance.

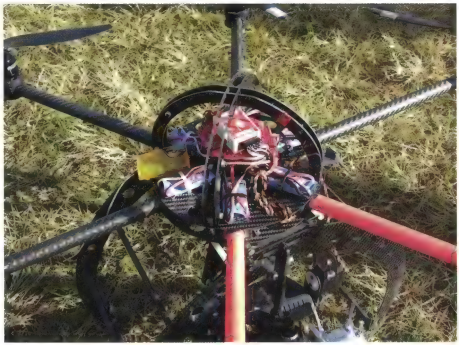
Lithium polymer batteries

There is an enormous amount of technology and development that has needed to come together to make these tiny fully autonomous machines possible. From the satellite-based GPS system through micro-miniature electronics to tiny electric motors and batteries, all have played their part.

However, from a purely practical, operational viewpoint the underlying technology which has made the Nanoquads possible is the lightweight, high energy density lithium polymer battery.

These batteries have completely altered the miniature aircraft landscape. For the first time, electric powered model aircraft are successfully challenging the internal combustion (IC) motor's position of supremacy; at least in the field of short endurance flying operations. This is the "Achilles heel" of electric powered aircraft; endurance!

Until battery manufacturers manage to produce batteries or power sources with energy densities similar to liquid fuels, electric powered flight will remain the "country cousin" of IC engines. That said, however, even a twofold or better increase in battery energy density will open up all sorts of possibilities for electric powered flight. That is how close the battle is balanced. As an example, almost half of the models used in the recent World Aerobatic championships, a typical short endurance event, were powered by electric motors.



Modern RPAs have only become possible with the miniaturisation (and power) of today's computers. The computer makes all the adjustments necessary (to motor speed especially) to actually keep the thing in the air!

The author, given equality in energy densities, would use electric power exclusively in his company's RPAs for a host of reasons including lack of vibration, reliability, low noise and ease of handling (starting and stopping the motor in flight, fuel cartage and storage etc).

In short, in many areas electrics leave ICs for dead but for long endurance RPAs at the moment electrics just simply do not cut it.

Thus we see that from the outset the electric powered quadcopter is primarily a short range and short endurance vehicle thus ideal for line of sight operations.

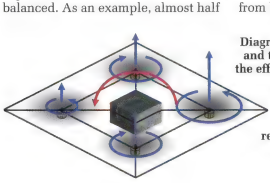
How does it work?

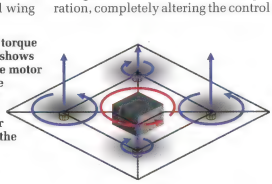
The quadcopter is quite different from both helicopters and fixed wing aircraft. With no fin, rudder, elevators, ailerons, collective or cyclic pitch, just how do these things work?

In the following explanation the description will concentrate on a simple quadcopter on the understanding that the same basic principles apply to all multi-rotor craft. Basically they consists of series of rotating propellers, some rotating clockwise and some rotating counterclockwise. The reaction between the thrust and torques generated by these propellers (or rotors) are used to stabilise and manoeuvre the machine as well as provide the lift required for vertical ascent.

For hovering flight, the torques must be in equilibrium and the thrust must equal the weight. Any imbalance in this equilibrium will result in a change in attitude or altitude with a resulting change in position.

As well as this the quad can be configured in the "X" or "+" configuration, completely altering the control





Diagrams showing the effects of torque and thrust. Diagram on the left shows the effect increasing thrust on one motor and reducing thrust on the opposite motor. Diagram right shows reducing thrust on the opposite pair results in a rotation around the Z axis.

It's not all fun and games: this RPA (equipped with camera) is relaying – in real time – close-up shots of this 50m mobile phone/microwave relay tower to the video operator on the ground (inset below). This operation requires two controllers – one "piloting" the plane with the second controlling the camera direction, zoom and focus while capturing the images required. This system also has huge potential in the movie/TV /advertising and commercial production area, too.

Here's the hi-res image transmitted from the RPA: crystal clear, perfect sharpness. Sure beats climbing a ladder!

inputs required to stabilise or move the aircraft.

The "+" configuration requires the control of two motors at a time for a change in horizontal position. If motor one decreases RPM and motor two increases RPM then the quad will move off in the direction of motor 1 (top of the page) due to the vectored thrust. Likewise left, right and backwards movements are achieved with the appropriate thrust vectors.

On the other hand X configuration requires less thrust on the two front rotors and more thrust on the two rear rotors to move forward. Both configurations then require Z-axis compensation to correct for the rotation induced by these thrust (torque) changes.

The quad therefore must be controlled in the X, Y and Z axes for positional placement as well as controlled to prevent rotation around these three axis. The rotation around the X, Y and Z axes roughly equates to the control of an aircraft in the Pitch, Roll and Yaw axes.

However, there is one very powerful difference. Any rotation around the X or Y axis will result in a thrust vector which will move the quad left, right, forward or backwards in the horizontal plane. Any imbalance around the Z axis will result in a rotation clockwise or anti-clockwise around that axis.

Thus control of all four rotors simultaneously is required to maintain the correct orientation of the quad in relation to the nominated reference point (eg, front of the quad).

For example, if a camera is mounted on the front of the quad with a simple single axis horizontal-to-vertical camera mount, the camera can be swung left or right by inducing a rotation around the Z axis by a change in the balance of torques.

Programming one of these little devils is not for the faint-hearted but fortunately most of the delicate control inputs required to hold equilibrium

No, it's not a computer simulation: it's a swarm of tiny RPAs, flying indoors, in a controlled formation with no risk of collision. . .

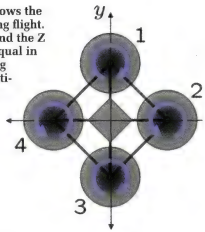


Fig.2: this diagram shows the conditions for hovering flight. with no rotation around the Z axis. All motors are equal in RPM with two rotating clockwise and two anti-clockwise and thrust equal to weight (not illustrated).

can now be taken care of automatically with modern inertial management unit (IMU) sensors.

Fortunately, with modern sensors, all of the corrections required can be programmed in as automatic responses. The overall effect in a correctly set-up quad is for a very stable camera platform, free of vibration and able to fly forward, backwards, sideways, up or down and rotate around its own axis.

Thus the requirement for a complex gimbaled camera mount can be reduced to a simple single axis mount moving the camera from horizontal to vertical, resulting in a great saving in weight and complexity.

We've focused on the small electric-powered quad-rotor but these machines can be quite easily fitted with standard IC engines and built to any size, as we have seen from the early efforts undertaken in the 1920s although the thought of starting and tuning four model-sized IC motors is quite daunting.

Just what the future holds for multi-rotor machines remains to be seen but you can rest assured . . . we ain't seen nuthin' yet! SC

A tiny video camera can be fitted to all but the smallest RPAs to relay images back to earth. It's shown here (left) mounted in the end of one of the radial arms. By contrast, the large RPA shown above left was fitted with the latest Canon EOS 650D digital camera, complete with 18-55mm zoom lens, on a tilt and pan gimbal. All aircraft and camera functions are controllable from the ground.

NEXT MONTH: We'll look at another RPA, an electric Piper Cub, fully kitted out for remote piloting and photography. We'll also look at some "real world" flying situations.

RPA OPERATIONAL GUIDELINES

The instruction issued by the US congress to the FAA states that RPAs under 55lb (25kg) are to be allowed into shared US airspace by 2015 with small RPAs under 2kg, later upgraded to 11.3kg) operated by emergency services to be given permission within 90 days.

This is expected to lead to an explosive growth in people and companies queuing up for Company Operating certificates and Remote Pilot Licenses (RPL).

In the US, the 90-day set of FAA rules will apply only to Police and other first-responder RPAs smaller than 25 pounds (11.3kg) that are flown in daylight below 400 feet, and that stay within line-of-sight.

There are several police forces here in Australia investigating RPAs and the multi-rotors are of great interest to the TV media. Of special interest in this stampede towards RPAs is the quadcopter.

Here in Australia, the Author has been a part of the team developing the CASA Level 1 RPL and it has been a very interesting project indeed. The Level 1 license covers operations carried out below 400 feet, visual line of sight (VLOS), Day Visual Meteorological Conditions (VMC), 3nm from an aerodrome and not over populous areas.

There is also talk of a weight limit of 55lb, certainly in the USA, while in Australia at the moment that current limit is somewhat higher. The aircraft that fits most easily into these regulations and with the widest application is the small multi-rotor and thus the majority of people lining up to be issued for the RPL Level 1 are multi-rotor operators.

For the hobbyist SGMA (self-guided modeal aircraft) operator, the Model Aeronautical Association of Australia (MAAA) has proposed a set of guidelines (MOP067) for what they term SGMA. Briefly, these guidelines propose a weight limit of 5kg with motor size limits (Electric and IC) and operations carried out below 400 feet, VLOS, Day Visual Meteorological Conditions (VMC), and on MAAA approved flying fields. For the complete MAAA policy follow this link: **www.maaa.asn.au/maaa/mop/policy/MOP067%20-%20Policy%20SGMA**

It is interesting to note here the MAAA definition of line-of-sight. The MAAA specifies that the pilot must be able to tell the model orientation at all times, should he be forced to resume manual control as below.

MAAA SGMA VLOS Definition: the maximum range at which the Pilot in Command can clearly determine the orientation and also manually control the Model Aircraft in sustained flight. CASA CAR (1998) Part 101 states that "a person may operate a model aircraft only if the visibility at the time is good enough for the person operating the model to be able to see it continuously" (101.385).

For those interested in the differences between SGMAs and RPAs from CASA's perspective, this link tells the story: **http://casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_100375**

Of particular importance for all RPAs and SGMAs is a return to launch (RTL) feature which is initiated automatically upon loss of the data link or manual control.

Also the autopilot should automatically return the aircraft to launch should the RPA or SGMA exceed an operator pre-determined distance from home (eg, the pre-determined MAAA defined VLOS distance for that particular model).

All small commercial autopilots also have an added legislated, anti-terrorist feature built-in, that being a RTL if 300km distance from home is exceeded.

NICHOLAS VINEN
gets to play!

Parrot AR Drone 2 Quad-Copter

This impressive flying beast sports four rotors and two cameras. You can control it with an iPhone, iPad or Android device and capture 720p video of its exploits. It's quite robust, easy to fly and has multiple control modes to suit different pilot experience levels.

There are plenty of build-it-yourself kits out there now for quadcopters – but building your own isn't for everyone.

For those who want to have the fun without doing much work, the AR Drone 2 comes fully pre-assembled and it has many impressive features. Chief among these is the high definition wide-angle video camera with live streaming as well as recording to a USB flash drive.

The main part of the drone houses the electronics and battery. Four carbon fibre tubular arms project from this with the rotors, motor drivers and motors at the end of each.

You then slip one of the two expanded polypropylene "hulls" over the body, which protects it from damage in the event of a minor accident or collision.

The "outdoor hull" only covers the electronics and battery, leaving the rotors exposed. This gives the best flying performance because it's quite light. It also means that if you fly too low, you might end up mowing the lawn!

The "indoor hull" is larger and surrounds the rotors entirely as well as providing more protection to the main body. This reduces the chance of major damage in the event you strike a wall or some furniture.

We found the AR Drone 2 to be pretty robust, especially with the indoor hull in place. With it, it can shrug off minor impacts with obstacles; if you don't hit them too hard, you can continue flying, often without any damage.

This is of course great for beginners, who will probably have a few mishaps before they get the hang of controlling the Drone.

It also has an an automatic motor cut-out if the unit experiences an impact, tilts past a certain angle or detects the rotors hitting an object. The unit will normally survive the resulting fall without any serious damage as long as it isn't too high and/or the ground below it is reasonably soft (eg, grass). We had this feature activate a few times with our demo unit and each time, it was still perfectly flight-worthy.

This is thanks to its sturdy construction and energy-absorbing arm mounts; one arm usually takes the brunt of any impact.

The hull, being made of a foam material, is the most likely part to break but if does split, it can simply be glued back together. They even give you some double-sided tape in the box for field repairs, should they be necessary.

Stability and control

The AR Drone 2 is self-stabilising. When you press the take-off button, it rises straight up from the ground to a height of about one metre and hovers in place until you are ready to take control.

At any point, if you take your hands off the controls, it returns to a stable hover – this is great for beginners since if you lose control this is an easy way to recover. And if it's being blown away

Here's the more "decorative" version of the Parrot intended for outdoors flying where there's less risk of damage to walls, furniture, etc. It also has better performance than the "indoor" version with its polypropylene "hull". The colourful carapace also has an important outdoor benefit: it allows you to work out the PRA's orientation at a distance.

by wind or something like that, you can just press the "land" button and it will gracefully settle down onto the ground.

If it flies out of range, it will hover and wait for you to get closer. The stated range is 50m in an open space but we were able to control the demo unit out to a range of about 100m.

If the Drone's battery runs out during flight, it lands itself but you get a warning beforehand so you can fly it to a safe location for landing. If you're controlling it with a phone and somebody calls you, it will either hover or land, depending on whether you've set it to indoor or outdoor mode.

There is a LED in each corner of the Drone, underneath the rotors. In flight, the two at the front turn green while the others are red, so you can see which way it is facing.

Sometimes they can be obscured by other parts of the Drone and so it isn't always clear which way the Drone is facing just by looking at it.

If we owned one of these, we would think about fitting a bright blue LED under the camera to give a clear indication of which way it's facing or perhaps paint the front a bright colour.

With the outdoor hull in place, the front is a bit more obvious since it looks significantly less symmetrical than the indoor hull.

Performance

We found the AR Drone 2 to be fairly agile. It certainly can spin fast and it can move in any direction parallel to the ground at up to about 18km/h.

Its speed and manoeuvrability are impressive but having said that, we have seen some home-built quadcopters which are significantly more agile; this is mainly due to the fact that the AR Drone 2 uses surprisingly small 14.5W brushless motors while home-built drones tend to use more powerful units.

Beginners and recreational flyers should be satisfied with the performance. People who really enjoy flying the AR Drone 2 may then decide to build their own and use larger motors, to get real acrobatic performance.

Absolute and relative modes

You have two main choices of control mode, called "relative" and "absolute". Absolute control is rather clever and it's what we prefer to use if you are flying the drone by looking at it, which is easier when flying indoors. In fact this is by far the easiest mode for beginners.

When you enable absolute mode, the software takes advantage of a magnetometer (ie, 3-axis compass) in both the AR Drone 2 and your phone/tablet to work our how they are orientated relative to each other.

Then if you tip the phone/tablet to your left (or in joypad mode, move your left-hand thumb to the left), the drone will move to your left, regardless of which way the drone itself is facing.

In this mode, you don't need to yaw the Drone at all, except if you want to aim the forward-facing camera in a particular direction.

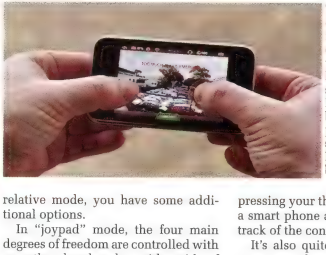
By comparison, in relative mode, the controls act depending on the direction the Drone is facing. This is the mode you need to control the Drone if you are looking at the camera feed, since your are then looking at whatever the Drone is facing. You can also use this mode without using the camera but this takes more concentration than absolute mode.

If you're going to be flying the drone out of direct line-of-sight then you will need to fly using the camera and hence will be using relative mode.

Note that the camera update rate depends somewhat on the speed of the processor in your control device; we found it much easier to fly using the camera on a fast Android tablet than we did with an iPhone, where the video update rate was rather sluggish.

Controls

Once you have chosen absolute or



The Parrot can be controlled via an iPhone (as here), iPad or Android phone/ tablet (although we had problems with some Android tablets). Essentially the Parrot becomes a WiFi access point – the pic on screen is what the Parrot sees via its on-board camera!

relative mode, you have some additional options.

In "joypad" mode, the four main degrees of freedom are controlled with your thumbs placed on either side of the smart-phone or tablet screen, as if it's a game controller. In this mode, your left thumb controls movement parallel to the ground, ie, moving forward and backward and "slipping" left and right. Your right thumb controls altitude (up/ down) and rotation left and right (ie, yawing). This can be swapped if you are left-handed.

In the alternative mode, the right thumb control is identical but forward/ back/left/right movement is controlled by tipping the phone or tablet. The software detects the tipping using its built-in accelerometer.

This is probably the easiest mode for beginners. But it's impractical if you are going to be using the video feed to fly the Drone since you can't really see the video while you are busy tipping the controller.

This combination, where one hand controls altitude and yaw and the other movement in the horizontal plane is similar to what is commonly known as "mode two" for helicopter control. But we tend to prefer "mode one", where one hand controls yaw and forward/ back movement and the other controls altitude and left/right movement. Unfortunately, the software does not seem to offer the ability to switch between these modes. This is a pity as it would not be difficult to do and many people will prefer mode one, which is commonly used in Australia.

Our other main complaint about the controls is that since the control "sticks" are virtual, you don't get any tactile feedback from them. With real "joystick" type controls, the centring springs let you know how far you have moved the stick from its neutral position without having to look at it. This is not the case when you are simply pressing your thumbs on the screen of a smart phone and so it's easy to lose track of the control positions.

It's also quite easy to accidentally move your thumbs outside the control zones, in which case the phone will beep to let you know you're not longer controlling the drone. This is why we tend to prefer using a proper remote control transmitter for this sort of job but then you would need a separate device to view the video feed from the Drone.

When configuring the controls for the AR Drone 2, you can set various parameters which limit the rate at which it moves, turns, how high it will fly and so on. The initial settings are quite low and presumably are intended for beginners, so they won't crash it too hard if they lose control.

However we found it a bit easier to fly the Drone with the limits turned up as it's then possible to make faster corrections to its flight path.

The AR Drone 2 also has a "flip" mode where it does a somersault, which can be used when hovering or during flight. It seems to be primarily useful for showing off!

This is activated by double-tapping the left control "stick" but can be disabled to prevent accidental activation if it isn't being used. An accidental flip at low altitude could cause quite a nasty crash.

Technology

The electronics behind the AR Drone 2 are impressive. The main controller module is powered by a 1GHz ARM Cortex A8 32-bit processor with an 800MHz video DSP and 128Mbytes of memory. This runs Linux and has a Wi-Fi interface. It is effectively a flying Wi-Fi access point!

To control the AR Drone 2, you first have to join its network. It is over this network that both control signals and video are sent.

Each rotor is driven by a separate brushless motor which, as mentioned earlier, produces up to 14.5W and is about the size of half of a AA cell. The motors are mounted on PCBs, each with an 8-bit Atmel microcontroller which drives the windings in sequence, controlling speed. These are in turn controlled by the main board over a serial bus.

For position and speed feedback, the controller effectively has what is known as a nine degree-of-freedom ("9DOF") sensor comprising 3-axis MEMS accelerometer, 3-axis MEMS gyroscope and 3-axis magnetometer.

This allows it to measure instantaneous acceleration, change in rotation and orientation and it is this information which allows it to automatically hold its position in a hover.

The stabilisation system can compensate for wind and other factors although note that it could be overwhelmed by strong wind gusts. The stabilising system also becomes less effective once the drone is more than six metres or so above ground level although we found it was still pretty good.

For more information on how the controller is able to stabilise and move the quadcopter through the air, see the accompanying feature article in this issue (page 21).

For measuring height, the AR Drone 2 sports both a pair of ultrasonic sensors on the underside as well as a pressure sensor for measuring altitude (with <1m resolution). It can measure its altitude at take-off and compare it to the present altitude to implement its adjustable height limit ("ceiling"). At lower levels, the ultrasonic sensors give it more accurate feedback.

The video quality from the main camera is good; the fast DSP allows it to do high-quality video compression in real time, which is necessary in order to get the video over the limited bandwidth of the wireless link.

It also has a downward-facing camera (320x240 pixels) which can be used to check whether it's safe to land the unit if you can't see what's immediately below it from your vantage point. A button on the screen switches the view between the two cameras.

As well as allowing you to see what's under the drone, the downward-facing camera is also used to estimate ground speed (in conjunction with the height measurement). This then lets you limit

The four motors are tiny – this shot from underneath shows one of the motors (circled) mounted on the arm which also houses the landing "foot", along with the motor control electronics. You can see the massive gearing down of the motor from the size of the propellor shaft gear versus the just-visible motor shaft gear.

the Drone's horizontal speed.

You can similarly limit its maximum angle of tilt (measured with the accelerometer) and rotation speed (via gyros). That's a lot of different things to adjust. In fact there are several screens full of settings you can play with.

Build quality

We weren't just impressed with the electronics in the Drone. Some clever mechanical and material engineering has also gone into the design.

The rigid parts are, well, rigid while other parts are designed to have some "give" to reduce vibration and absorb impacts. For example, the battery is suspended on a flexible bed in order to prevent its weight from affecting stability. The motor, arm and rotor assemblies are designed and made with precision. Even the foam hulls are accurately moulded.

One common problem with camera-equipped drones is image blurring due to vibration from the motors and rotors. We didn't see any evidence of this from the AR Drone 2 and according to Parrot, this is due to carefully designed flexible joints between the arms and main body which prevent vibrations from being transmitted to the camera. It seems to work well.

Software

We found the software easy to install and set-up on an iPhone and we expect it will be just as easy on an iPad. We didn't run into any problems with the iPhone software; it's responsive, logical and easy to use. Ideally you would use a tablet since the iPhone screen is a little small to view the video, especially with controls and read-outs partially obscuring it. The iPhone also gave a slow video update rate.

The Free Flight software is also available for Android and is virtually identical to the iPhone/iPad application. It requires Android version 2.2 or later as well as a multi-touch screen and accelerometer.

We expect most Android devices would meet these requirements but surprisingly, of the four we tried, it would only install on one.

The version requirement is a bit of a problem since even some fairly new Android phones are only running on version 2.1; the Publisher has one and it's only just over a year old. Two others we tried were running version 4.3 and appeared to meet the requirements but the software refused to install, in each case saying the device was not supported.

On an Asus Transformer (Android), the software worked quite well with the exception that a couple of times we got stuck in piloting mode and had to "kill" the application to get out of it.

It could have been worse; at least if you're stuck in piloting mode, you retain control of the drone. The video quality and update rate were very good on the Transformer.

If you have an Android phone or tablet and are interested in the AR Drone 2, your best strategy is to install the software first and check that it works before you buy the hardware. To do this, just follow the link to the free software from the Parrot website at http://ardrone.parrot.com/parrot-ar-drone/

Hopefully, the compatibility problems and software glitches will be sorted out with a software update. Oh, and Parrot also provide firmware updates for the Drone itself, should this be necessary.

Battery

The AR Drone 2 comes with a 3-cell, 1Ah Lithium Polymer battery which is good for about 12 minutes of flight. The software has a battery meter in the corner of the screen so you can keep track of the charge state while flying. This battery clips into a plugpack-style balance charger and it charges reasonably quickly – up to about 90 minutes, but usually less than an hour unless you've run it right down.

That's pretty good but if you want to take the Drone out to a park for an extended flying session you will probably want to buy some spare batteries.

Parrot insist that you only use their batteries but a little birdie told us that you can use other 3-cell Lithium Ion/Polymer batteries if you make a suitable adaptor cable.

Spare parts

Most of the AR Drone parts are available as spares so that you can repair it if you have a prang. Having said that, careful pilots should not need to be replacing parts very often given its overall robustness. Mostly minor impacts just result in some scratches or maybe split the hull; as beginners we had a number of "oops" moments with our demo unit but only did relatively minor damage to the hull.

Inevitably most owners will eventually end up breaking something that you can't fix with tape. When you do, you can get replacements for most of the parts from their website (URL below). They also sell a range of accessories to customise your Drone or play games with it.

Conclusion

The AR Drone 2 itself is an impressive piece of gear, well-built and cleverly designed with a lot of excellent features.

The story with the software is not quite as rosy although if you manage to get it installed, you shouldn't run into many issues. We hope and expect that the Android application will receive some improvements in the near future.

If you're looking for a well-made pre-built drone that's fun to fly and with lots of features, the AR Drone 2 is hard to beat.

Price & availability

The AR Drone 2 retails for $349 and is available for purchase at their website: http://ardrone.parrotshopping.com/au/p-ardrone-main.aspx

It is also available from many electronics and hobby retailers. SC

RPAs in Action:

By Ross Tester

Designing, building and using RPAs for business

SILICON CHIP talks to (while we watch in awe!) two young men who are dedicated RPA hobbyists turned businessmen: they are setting up a company specialising in aerial cinematography for movies and TV using RPAs – one of the first in Australia to do so.

On page 22 we showed an RPA – in this case a large octocopter – taking photographs at the top of a 50m-high communications tower and relaying the images back to ground operators in real time.

That particular octocopter – a huge thing compared to the Parrot we reviewed – is one of several belonging to Matt Chang and Peter Maruncic. They've formed a business called "Rotorworks" to use RPAs in film, TV and advertising production, giving producers and directors hitherto impossible-to-obtain aerial shots and angles, at dramatically lower cost than traditional methods.

"Previously only a real helicopter could get the angles but could never approach to such intimate close-up distance that we can achieve with our octocopter," said Matt.

With 35+ years of RC aircraft experience, Matt is the Chief UAV controller who will be certified to fly the octocopter, while Peter with 25 years RC experience is the Aerial Video operator and UAV controller.

Matt was one the first UAV Operators certified back in year 2000 with the pioneering use of RC blimps for aerial advertising.

With multi-rotor technology now available and certification to operate commercially in Australia, they are in a unique position to shoot aerial angles that have never before been available to the cinematographer without significant investment in manpower and costs.

"We can fly indoors or outdoors and we can get her moving up to about 60km/h or faster if required for high speed tracking shots."

"Importantly, we can shoot in high-risk locations in complete safety and zero risk to people, with almost zero set-up time. For example, it's simple for us to hover off a cliff face, above a tree or under a bridge. We can also take off and land on a moving boat. Shots over water are another great aspect of what we can offer, even take off and landing on water if required."

Aircraft

Matt and Pete currently have about seven multi rotor aircraft of all types that carry all types of cameras, from a tiny GoPro to large Epic.

The smallest craft can fly through narrow doorways and windows if required, while still carrying a camera (albeit a small one)!

Invasion of the RPAs! While the smallest of these are virtually hobby machines, they are still capable of taking a small camera aloft. But the real work is done by the hexacopter (at rear) and the octocopter at front. The orange-coloured radial arms assist the operator in orienting the craft from a distance – they're mounted facing forward (same direction as camera).

The Octocopter

Of most interest to us was their giant octocopter, an eight-rotor electric-power RPA developed specifically for cinematography.

It uses very powerful brushless motors and is quiet compared to past technologies. An onboard computer stabilises the craft while movement is controlled from the ground.

The octocopter can fly for 10-15 minutes at a time, depending on the manoeuvres required. Batteries can be swapped for near-continual flying if needed. Battery swap time is approximately three minutes.

Onboard is a GPS which allows Matt to do a number of things to aid in filming:

- GPS position hold: locks at any altitude and position above the earth.
- GPS return home: with the press of a button, the octocopter will return home and land automatically; this is a great feature for safety.
- GPS Circle waypoint: it can circle a point chosen anywhere on earth, all while the camera is pointing in towards a subject.
- Follow Me: The octocopter can follow the controller automatically as they walk or drive at a speed of between three and ten metres per second.
- Point-and-click-to-fly is also possible from a ground station. One click with the mouse on a Google map and the octocopter flies there.

Cinematography

In terms of cameras, the respective aircraft can carry anything from a GoPro, which weighs a couple of hundred grams, to a Red Epic which weighs 2kg plus lens.

An even bigger machine could be built if a client wanted the craft to carry two Epics for 3D work.

The camera gimbal uses high speed servos to level the camera platform and can control its roll, tilt and pan. There's also an onboard computer that takes care of camera stabilisation which updates 800 times per second to provide rock-solid stabilisation. Continuous and unobstructed 360° filming is possible.

Recording is done on-camera but there is also a live full-video pass-through transmission that the camera operator uses on the ground.

If required, it can relay HD video to the ground but there is a weight penalty, which reduces endurance.

Safety

In terms of safety and insurance, they offer $10-$20 million Professional Indemnity Insurance from an Aircraft Insurance company.

Flying is limited to dry conditions and wind less than 20 knots, with a height restriction of 400 feet,

This could be a great opportunity for customers as they are one of the first companies that will be able to do this legally in Australia, as officially certified by CASA.

Currently in the US there is no provision for any form of licence to use these aircraft so we feel very lucky that Australian laws permit this type of operation.

Contact:

Rotorworks (Matt Chang & Peter Maruncic)
Phone: 0405 902 033
Website: www.rotorworks.com.au

Hover mode: the hexacopter remains completely still while the operator's hands are off the controls. This aircraft has provision for a camera though none is fitted.

Matt and Peter tell us about their aircraft and systems. . .

The small Quadcopter airframe we flew is called a Kinjal and is made from carbon plate and computer motherboard standoffs.

The brains behind the act is what we call a Flight Controller or FC. The particular one demonstrated doing aerobatics is called Quadrino and is one of the many flavours of "MultiWii" based flight controllers currently available.

The Wii in MultiWii stems from the original use of the gyro and accelerometer in the Nintendo Wii Motion Plus and Nunchucks. Those gyro and accelerometer boards are stripped out and hooked up to Arduino boards. MultiWii is one of many open source flight controller software projects and is based on the Arduino platform.

Originally started in 2010 by RCGroups user "AlexinParis" the software development has a huge following and the RCGroups MultiWii thread currently runs at 27,500 posts.

The Multiwii software supports a 3-axis accelerometer, 3 axis gyro, 3-axis magnetometer, barometer and a GPS. Various forks of the software support other extras such as LED lights and ultrasonic sensors. You can learn more about it here:

www.rcgroups.com/forums/showthread.php?t=1261382

A large index of multi-copters and software developments can be found here: www.rcgroups.com/forums/showthread.php?t=1097355

In the world of ready-to-fly flight controllers there are a few that seem to have had commercial success: MikroKopter (MK), Hoverfly, DJI Innovations and the newcomer, ZeroUAV.

MK is developed by Holger Buss who was one of the first to develop an affordable commercial solution good enough for aerial photography and video.

We fly with a DJI Flight controller called Wookong which is easy to set up and flies well out of the box. It's also expandable from the default GPS and attitude hold, through to multi-waypoint navigation systems with a ground station.

All of the features are locked up onboard and after an on-line payment, DJI unlocks the extra features with a special serial code.

The Newcomer ZeroUAV has really given DJI a run for its money as it is developed by an ex-employee of DJI. The ZeroUAV YS-X6 has some great features such as WiFi telemetry downlink to your iPhone or Android device; FollowMe allows the multi-copter to literally follow you by tracking your iPhone's position and circle mode which circles a point on earth while pointing the camera at the centre point. With the introduction of these great features, DJI seems to have become more competitive and will introduce some exciting new features soon. It's a good time to be in this hobby with such rapid development in all areas of the hobby.

The DJI and ZeroUAV solutions have some very tricky ways of insulating the onboard circuitry from the airframe's vibration by mounting the gyros and accelerometers onto a small metal and lead covered block.

The take-apart guides are here: Wookong technical review – www.rcgroups.com/forums/showthread.php?t=1510587

ZeroUAV technical review – http://www.rcgroups.com/forums/showthread.php?t=1676150

Our Wookong powered octocopter uses eight brushless motors powered by eight 40A ESCs (Electronic Speed Controllers). Thrust generated with our setup peaks at just over 10kg.

The Motors run at 770 RPM per volt which equates to a real-world RPM of about 7500 when hovering. Our starting voltage is about 16.8V on a fully charged (4 cell) LiPo (lithium polymer) battery and we land when it's about 13.2V. Any lower than that starts to deteriorate the batteries permanently. Our endurance with

The small Kinjal quadcopter is capable of unbelievable aerobatics.

16Ah of battery capacity is about 12 minutes.

The frame, made of carbon plate, was developed in-house and cut on a DIY 3-Axis CNC milling machine. The booms that secure the motors are aluminium and carbon fibre.

We use very light weight carbon fibre propellers which can react quickly to keep the multi-copter balanced, as instructed by the flight controller.

With all that payload potential we can lift a gyro-stabilised camera platform or gimbal. Our gimbal is made by Photohigher of NZ who have developed an amazing system to stabilise the camera platform. The controller board is attached to the camera tray and uses its accelerometers and gyros to maintain a level camera platform at a rate of 800Hz. When tuned, camera stabilisation is near instantaneous.

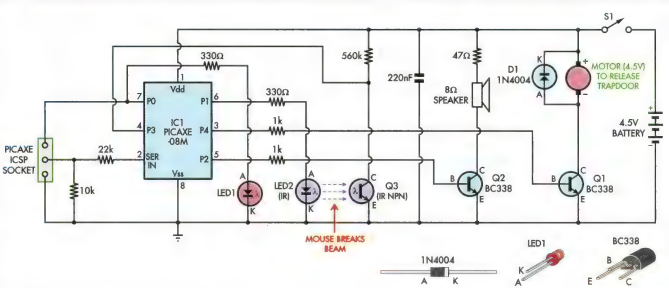
There are only a few certified UAV operators in Australia who are legally permitted by CASA to operate commercially and shortly we will have earned our Operator's Certificate too.

It's worth noting the amazing change in RC Hobbies with the recent growth of the famous Chinese based powerhouse of hobbies "Hobbyking.com". Their RC products are all sourced direct from the manufacturers so have dramatically reduced in prices, and entry into the hobby is more affordable than ever before. For example, where batteries like we now use used to cost upwards of $150 each, they now cost in the realm of $15 to $40. SC

The octocopter is made of lightweight materials but with batteries, camera and all the control gear it's still a handful!

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



PICAXE-based mouse trap is non-lethal

This mouse trap uses an IR LED and phototransistor coupled with a PICAXE08M microcontroller to operate a small motor that closes a trap door. This design avoids the main problems with traditional spring-based traps, in that they are difficult to set and often fingers are caught during setting up. Secondly, the sneaky mice often eat the bait without setting off the trap.

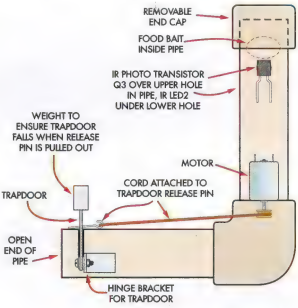
This humane trap is constructed from two short lengths of 25mm PVC pipe, with a right angle elbow in the middle and a snug-fit removable cap at one end. The bait (usually chocolate) is placed at the cap end. About one centimetre from the other end of the pipe assembly is a slot for the trap door that is cut half way through the pipe.

The trap door is cut out of some sheet metal to fit the internal curve of the pipe and arranged so that it can pivot into the pipe and seal the exit. A 2mm diameter hole in the door and a pin in the shape of a threaded eyelet is inserted to keep it open. The pin is connected to the shaft of the motor via a short cord.

When the trap is triggered, the motor is energised for a short time, wrapping the cord around the shaft and pulling the trap door pin out to release the door, with gravity closing it.

The mouse detection circuit is located at the bait end of the trap and comprises an IR LED opposite an IR phototransistor. When the mouse breaks the beam, the trap door is closed.

The IR LED and phototransistor were sourced from an old disk drive. Similar photo-interrupter components can be found in printers and can be separated easily to be placed apart so that the mouse can interrupt the IR beam.



At power on, a short tune is played and a red LED is flashed. After this sequence, the red LED flashes to indicate normal operation. The IR LED is also pulsed briefly at the same time, to prolong battery life. When the IR beam is broken, the motor is energised for a short duration to close the trap and the tune "Silent Night" is played to notify successful operation. The tune is repeated at 15 minute intervals.

The captured mouse is not harmed and can be released by removing the snug fit end cap. The trap could be adapted for other animals by suitably scaling up of the pipe and other components. Power comes from three 1.5V alkaline AA batteries.

The software, MoustrapV4.bas, is available for download from the SILICON CHIP website.

Phillip Webb,
Hope Valley, SA. ($60)

Jack Holliday is this month's winner of a $150 gift voucher from Hare & Forbes

7-day programmable alarm clock with 230VAC switching

The motivation for this project came from a desire to have a clock radio alarm in which each day's alarm can be individually set. Clock radios are not available with this facility so this design is the result. It uses a PICAXE18M2 microcontroller to perform the clock and switching functions. S2 is the Mode switch and its Run position is for normal clock operation while the Minutes, Hours or Days positions are used to set the clock or alarm, depending on the setting of Function switch S1.

The PICAXE drives a 16-character 2-line LCD (Jaycar QP-5516). The top row shows day and time (AM/PM format) and a flashing heart-beat symbol (Ω) when in clock mode. The bottom row displays the day and the alarm-on time and alarm-off time in 24-hour format for that day, as well as an asterisk symbol (*) indicating whether the alarm is set or not. Switch S3 sets the alarm ON or OFF.

S4 is a DPDT momentary switch with centre-off (Jaycar ST-0358). In the Set position, the parameter selected by S1 and S2 is incremented; the switch being returned to the centre position when the desired value is reached.

When all the alarm information has been set, S4 is momentarily put into the STORE position, whereby an interrupt routine in the software stores the alarm information for that day. The LED also turns on as a visible confirmation. The alarm information is stored in non-volatile memory so it isn't lost if power is disconnected.

The PICAXE18M2 has a TIME variable which increments every second. This could have been used as the basis for the clock operation but because of systematic error in the internal oscillator, such a clock will gradually drift out of time and will need to be reset periodically. For this reason, the timing circuit is based on the 50Hz mains supply.

Positive-going 50Hz pulses are delivered via diode D2 to the clock input, pin 10, of IC2, a 4020 CMOS 14-stage counter. This is teamed with gates IC3 & IC4 to produce one pulse every minute from pin 4 of IC4b. These pulses are applied to the reset pin of IC2 (pin 11), which resets the counter and it starts again.

The reset pin is also connected to the B1 output of IC1. This is to allow the software to reset IC2 after the time has been set and the Mode switch is returned to the RUN position. This ensures accurate time-setting by forcing the first minute to be the full count of 3000 pulses.

The narrow pulses at pin 4 are stretched to about 7s by IC4d and IC4c to ensure that IC1 has ample time to detect them. The detection of the timing pulses at pin 10 is carried out using a parallel processing routine which ensures that no pulses are missed due to the processor being busy doing other tasks.

The power supply is straightforward but the 7805 regulator will need a heatsink if an LCD panel with a backlight is used.

The alarm function can be manually switched on or off using switch S3. If it is in the Auto position, the programmed alarm times are executed. If the DAYS are cycled through with the Alarm switch in the Off or On position, the display will show the alarm settings stored in memory for each day. This allows the current alarm settings to be viewed.

On the other hand, if the DAYS are cycled through with the Alarm switch in the Auto position, when each new day is selected, the Alarm setting for the previous day is displayed. This facilitates alarm setting as it is often the case that one day's setting is also required for the next (eg, Monday to Friday might all be the same).

Finally, if the alarm for a certain day needs to be cancelled, just increment the Alarm On hours for that day. After cycling through the hours up to 23, the next increment will display "no alarm". Just use the Store switch to store this condition and the alarm will not operate for that day.

If the alarm needs setting on a day showing "no alarm" just use the Set switch on any alarm setting selection and the display will revert to a zero display for all alarm values which can then be incremented and stored in the usual way.

The software, ClockLCD1.bas, is available for download from the SILICON CHIP website.

Jack Holliday,
Nathan, Qld.

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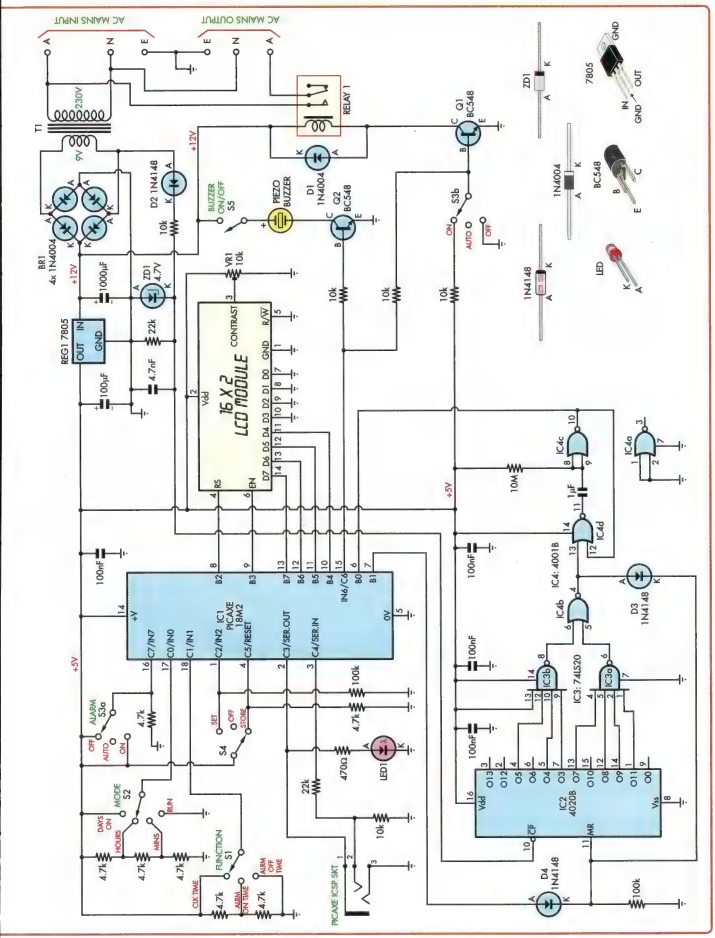
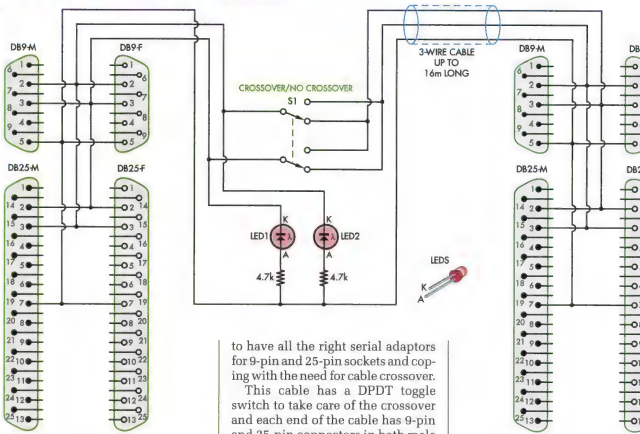

AC MAINS INPUT
AC MAINS OUTPUT
T1
230V
9V
RELAY 1
Q1 BC548
Q2 BC548
D1 1N4004
D2 1N4148
BR1 4x 1N4004
BUZZER ON/OFF S5
PIEZO BUZZER
ZD1 4.7V
REG1 7805
OUT IN GND
VR1 10k
16 X 2 LCD MODULE
CONTRAST
Vdd
RS
EN
R/W
GND
D0 D1 D2 D3 D4 D5 D6 D7
ZD1
1N4004
1N4148
BC548
7805
GND
IN
OUT
LED
S3b
ON
AUTO
OFF
IC1 PICAXE 18M2
+V
0V
C7/IN7
C0/IN0
C1/IN1
C2/IN2
C5/RESET
C3/SER.OUT
C4/SER.IN
IN6/C6
IC4: 4001B
IC4a
IC4b
IC4c
IC4d
D3 1N4148
IC3: 74LS20
IC3a
IC3b
IC2 4020B
Vdd
Vss
CP
MR
D4 1N4148
LED1
PICAXE ICSP SKT
ALARM S3a
MODE S2
FUNCTION S1
SET
STORE
DAYS ON
HOURS
MINS
RUN
CLK TIME
ALRM ON TIME
ALRM OFF TIME
+5V
+12V
1000µF
100µF
22k
4.7nF
10k
100nF
10M
1µF
100k
470Ω
4.7k



Serial cable for old computers

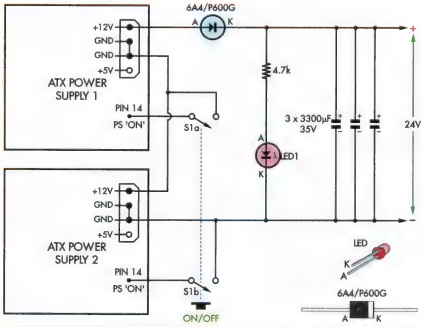
This cable adapter was developed from a need to send files to and from a PC to various vintage computers and to avoid the frustration of having to have all the right serial adaptors for 9-pin and 25-pin sockets and coping with the need for cable crossover.

This cable has a DPDT toggle switch to take care of the crossover and each end of the cable has 9-pin and 25-pin connectors in both male and female, so you will always have the correct connector available.

To use it, connect both computers and power on. If both LEDs are lit, then the crossover setting is correct. If not, change the toggle switch setting and when both LEDs are lit, communication can proceed.

The two 4.7kΩ resistors limit the LED currents to about 2mA, to avoid excessive loading of the RS-232 signal.

Russell Horswood, Maroochydore, Qld. ($30)

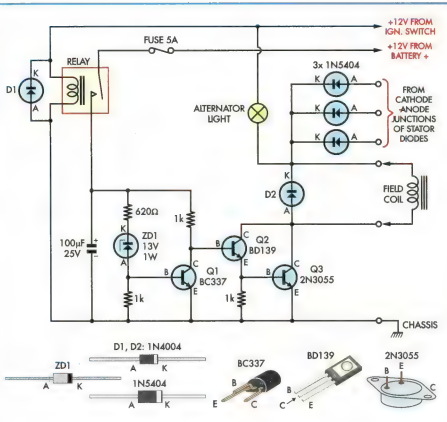


Recycled PC power supplies deliver 24V

This simple circuit shows how two ATX computer power supplies can be operated with their 12V outputs connected in series to deliver 24V at a high current (depending on the ratings of their 12V outputs).

Essentially, the two 12V outputs are connected in series and both power supplies need to be started simultaneously by grounding their start inputs, with a momentary contact DPST switch (S1).

Before the supplies are connected together, first check that each one is working. To do this, apply 230VAC to their input and monitor the voltage (+5V) on pin 9 of the 20-pin socket. Then connect pin 14 of the same con-



Voltage regulator for Mitsubishi van

This circuit was produced to replace a failed voltage regulator on an old Mitsubishi Express van in order to avoid the high cost of a replacement module. It works the same as a conventional regulator on a typical alternator in that the current through the field winding is varied to keep the alternator's output voltage within a narrow range.

The battery voltage is monitored via a 5A fuse and the contacts of the relay. It is then filtered with a 100µF 25V capacitor and fed via a 620Ω resistor to a 13V zener diode (ZD1) which biases transistor Q1. It works as follows:

When the battery voltage is below 13.6V, no current flows through ZD1 to the base of Q1, which remains off. This allows transistor Q2 to conduct and bias on Q3, a 2N3055 power transistor. This supplies maximum current to the field coil of the alternator, to maximise current to the car's electrical system and to the battery.

As the battery voltage progressively rises above 13.6V, Q1 is turned on and it throttles back Q2 & Q3, reducing the field current and thus the alternator's output. The result is that the regulator holds the output voltage close to 14.2V when the engine is above idle speed, even with 100W of driving lights and other loads on the system.

The unit was built on a PCB and installed in a diecast aluminium box which acts a necessary heatsink for the 2N3055. The failed regulator was left in situ in the alternator case with its terminations cut off. The three 1N5404 diodes connect to the alternator's stator leads.

With this circuit, there is some RF interference affecting the reception of distant AM stations. This can be remedied by fitting a suppressor to the B+ terminal on the alternator (if one is not already fitted). Shielding the flying leads can help in stubborn cases.

Geoff Coppa,
Toormina, NSW. ($60)

contribution
May the best ~~man~~ win!

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nector to GND and the internal fan should run, signifying that it is OK. Check the 5V and 12V outputs on both supplies.

The circuit includes three 3300µF 35V capacitors to provide additional filtering. Schottky diode D1 is included to prevent the capacitors from discharging back into the ATX supplies when power is removed. This could blow one or both supplies if power is accidentally removed from one at switch-off. In practice, both supplies should be connected into one box and and their mains inputs wired in parallel.

You can use HDD sockets with four power supply leads (+5V, GND, GND, +12V) for connecting and feeding devices.

Alexey Uskov,
Vladivostok, Russia. ($40)

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The Driveway Sentry Mk.2

Here's an improved version of the Driveway Sentry we described in the November 2004 issue of SILICON CHIP. It detects vehicles like cars, trucks, tractors or other farm machinery moving along a driveway or through a gateway. When movement is detected, it switches on a mains-powered or battery-powered lighting system and activates an optional piezo buzzer alarm for a preset period ranging from 2-25 seconds.

The Driveway Sentry Mk.2 circuit is housed in a plastic zippy case and switches on lights when a vehicle drives over a driveway detector loop.

By Jim Rowe

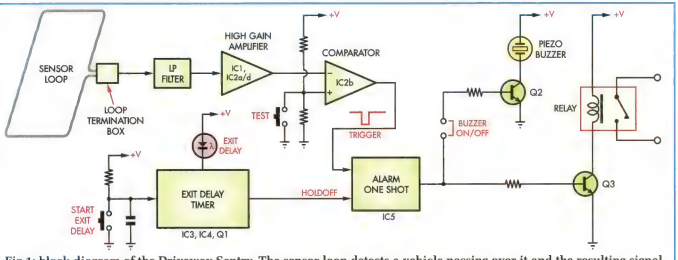


Fig.1: block diagram of the Driveway Sentry. The sensor loop detects a vehicle passing over it and the resulting signal is filtered, amplified and fed to comparator stage IC2b. This then triggers a monostable which turns on transistors Q2 & Q3 to drive a buzzer and activate a relay to switch on the lights.

UNLIKE OTHER motion-sensing systems that use light, heat or ultrasonic sound waves to detect motion, the Driveway Sentry Mk.2 operates by sensing small changes in the Earth's magnetic field – the same magnetic field that's sensed by a compass.

Since cars, trucks and similar vehicles contain a significant amount of ferrous metal (iron, steel etc), they inevitably produce small temporary changes in the Earth's magnetic field when they move into or through an area. That's how the original Driveway Sentry detected them and that's how this new Mk.2 version works too. The original unit used a special high-sensitivity shielded remote sensor unit (no longer available) but this new version simply uses a loop of sensing cable buried under the driveway.

No interference

Because it doesn't generate any sensing fields of its own, the Driveway Sensor Mk.2 produces no electromagnetic interference; it's quite "clean". Also, because it only senses moving iron and steel objects like vehicles, it's much more selective than other kinds of sensor. This makes it virtually immune to false alarms from birds, dogs, cats, sheep, kangaroos and other animals, falling tree branches, rain and snow, people walking past (unless they're Iron Man!) and so on.

At the same time, it can be used to detect the movement of vehicles which contain very little steel – like aluminium trailers, boats and caravans – simply by attaching a strong magnet to the underside of their chassis. The magnet ensures that if they're moved past the Driveway Sentry's remote sensor loop, the Earth's magnetic field will be disturbed locally and the system will activate.

In short, like the original Driveway Sentry, this new version has a multitude of motion-sensing uses around the home or farm. The system operates from 12V DC and draws very little current – less than 15mA when armed and waiting, and no more than 100mA when it senses movement and

Main Features

The Driveway Sentry Mk.2 detects moving vehicles by sensing the small temporary changes in the Earth's magnetic field caused by this motion. It detects the changes using a rectangular sensor loop which is buried under the driveway, or concealed with two opposite ends of the loop in the expansion gaps in the driveway itself.

Exit Delay: allows the system to be switched to non-sensing "sleep mode" for a period of about five minutes, to allow the owner's vehicle to exit from the property without activating the Driveway Sentry. At the end of the Exit Delay, the system returns to its movement sensing mode.

Test Button: allows the system to be manually triggered into "movement detected" alarm mode without having to drive a vehicle over the remote sensing loop. This makes system adjustment easier and more convenient.

Piezo Buzzer: produces a high-pitched sound to attract your attention when movement is detected. This sound can be disabled if you prefer the system to respond silently.

Relay Contacts: includes an SPST relay with mains-rated contacts. The relay is activated when the system detects movement, allowing the unit to be connected to control mains lighting or other equipment such as a high-powered siren.

Alarm Duration Control: allows the duration of the system's "movement detected" alarm mode to be adjusted between a minimum of two seconds and a maximum of about 25 seconds.

Sensitivity Adjustment: allows the sensitivity of the Driveway Sentry to be adjusted over a wide range, so it can be set for reliable vehicle detection without being too sensitive and susceptible to false alarms.

Low Power Consumption: unit operates from 12V DC power (normally a plugpack), with a low current drain: <25mA in Exit Delay mode (<300mW), <15mA in armed mode (<180mW) and <100mA in alarm (movement detected) mode (<1.2W). This means that the system can also be operated from a 12V SLA battery and/or solar power in rural and other remote situations.

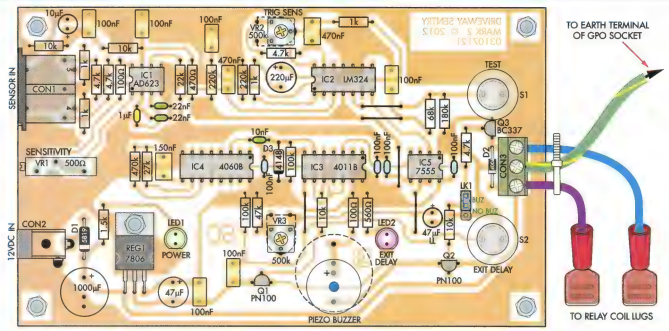


Fig.3: install the parts on the PCB as shown on this parts layout diagram. Take care to ensure that all polarised parts are correctly orientated and be sure to make the leads to the relay coil lugs at least 80mm long.

IC1. This bias voltage is derived from a voltage divider consisting of two 10kΩ resistors and is bypassed using 100nF and 10µF capacitors. It's then used to bias IC1's inputs via the 1kΩ resistors connected between pins 2 & 3 and 2 & 1 of CON1.

This means that there is virtually no DC voltage between the sensor loop conductors and their shielding, which improves the noise performance.

The amplified signals from IC1 emerge from pin 6 and then pass through another low-pass RC filter formed by a 22kΩ resistor and a 470nF capacitor. They then pass through IC2a, one section of an LM324 quad op amp that's used as a buffer to ensure that this RC filter is very lightly loaded. The buffered signals are then fed to the inverting input of IC2d via a 1kΩ resistor and a 220µF coupling capacitor.

IC2d provides the rest of the signal amplification, with its gain adjustable between five and 500 times via trimpot VR2. It also acts as a low-pass filter due to the 470nF feedback capacitor. Its -3dB point varies with the gain setting so that only signals below 40Hz are amplified.

Note that IC2d only amplifies the AC component of the signals, with their mean value set to +3.0V by a voltage divider consisting of two 220kΩ resistors.

From there, the greatly amplified signal from pin 14 of IC2d is fed via a 1kΩ resistor to pin 6 of IC2b, configured as a comparator. Here it is compared with a +4.4V reference voltage at pin 5, as set by a 68kΩ/180kΩ voltage divider. When the signal applied to pin 6 of IC2b exceeds this +4.4V reference level, IC2b's output (pin 7) switches low, providing a trigger pulse for monostable IC5, a 7555 CMOS timer.

The trigger pulse from IC2b is fed to pin 2 of IC5, while pins 6 & 7 are tied together and connected to a timing circuit consisting of a 47kΩ resistor, trimpot VR3 and a 47µF low-leakage capacitor. VR3 allows the one shot's "alarm time" duration to be adjusted from about 2-25 seconds.

When IC5 is triggered (ie, pin 2 pulled low), its output at pin 3 switches high. This turns on Q3 which in turn activates Relay1 to switch power through to the GPO mains outlet. At the same time, Q2 is turned on to activate the piezo buzzer, provided link LK1 is set to its upper position.

Exit delay

The exit delay circuit consists of a simple RS-flipflop (IC3b & IC3c) plus IC4, a 4060B 14-stage binary divider with its own clock oscillator. When power is first applied or when S2 is pressed, the flipflop is switched into its reset state (pin 4 low) by the temporary low on pin 8. This low on pin 4 is applied to the reset pin (pin 12) of IC4 and as a result, IC4 starts counting.

At the same time, gates IC3d and IC3a (used here as inverters) apply a logic low to pin 4 of IC5, its reset input. This prevents IC5 from triggering in response to pulses from IC2b.

The timer's counting proceeds for a little over two minutes, after which IC4's O14 (pin 3) output finally goes low. This negative-going pulse is coupled via a 10nF capacitor back to pin 6 of IC3b, which switches the flipflop back into its set state.

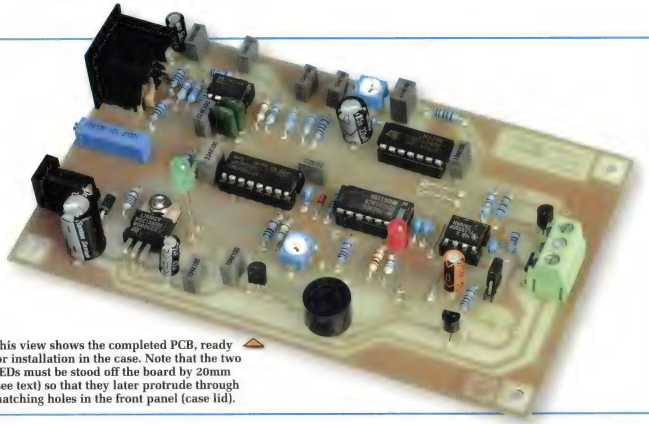
When this happens, pin 4 goes high and switches IC4 back into its reset state, thus stopping its oscillator and counter. At the same time, gates IC3d and IC3a apply a logic high to the reset pin of IC5, allowing it to be triggered again by any low-going pulses from IC2b. So the Driveway Sentry is armed (or re-armed) after a 2-minute delay.

If you want a longer exit delay, simply replace the 150nF capacitor with a higher value (eg, 330nF for five minutes).

During the exit delay time, there is a logic high on pin 10 of IC3c, the lower flipflop gate. This is used to turn on transistor Q1, which allows current to flow through LED2. This LED is therefore only illuminated during the exit delay period.

Power supply

The power supply section of the



This view shows the completed PCB, ready for installation in the case. Note that the two LEDs must be stood off the board by 20mm (see text) so that they later protrude through matching holes in the front panel (case lid).

Driveway Sentry is very straightforward. Power comes from an external 12V DC plugpack, with Schottky diode D1 providing reverse polarity protection. The output from D1 is decoupled using a 1000µF electrolytic capacitor and then fed to regulator REG1 which provides a stable +6V supply.

This +6V rail powers all of the circuit except for the relay which is powered directly from the cathode of D1. Diode D2 across the relay coil protects Q3 from damage by quenching any back-EMF spikes that are generated when the relay turns off.

LED1 provides power-on indication, with the 1.5kΩ resistor limiting the current through the LED to about 7mA.

Construction

The assembly is straightforward with most of the parts mounted on a PCB coded 03107121 and measuring 140 x 84mm. The only parts not on the board are the remote sensor loop, the output relay and the mains input and output connectors.

With the exception of the sensor loop, the parts are all housed in a standard UB2 jiffy box measuring 197 x 113 x 63mm. As stated, the remote sensor loop and its associated termination box connect to the main unit via a 2-core shielded cable.

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1.0µF	1µ	105
470nF	0.47µF	470n	474
150nF	0.15µF	150n	154
100nF	0.1µF	100n	104
22nF	.022µF	22n	223
10nF	.01µF	10n	103

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	2	220kΩ	red red yellow brown	red red black orange brown
❑	1	180kΩ	brown grey yellow brown	brown grey black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	68kΩ	blue grey orange brown	blue grey black red brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	4	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	1.5kΩ	brown green red brown	brown green black brown brown
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	1	560Ω	green blue brown brown	green blue black black brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	2	100Ω	brown black brown brown	brown black black black brown

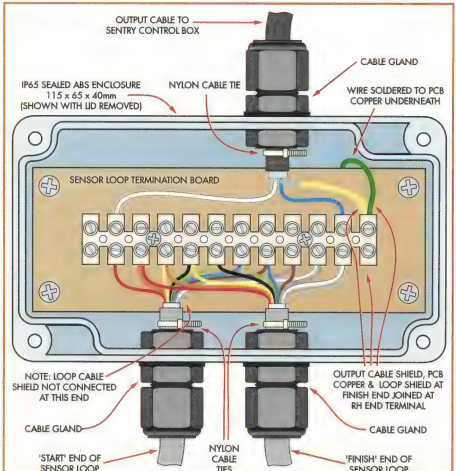


Fig.4: here's how to connect the wires from the sensor loop and the output cable inside the loop termination box. The 12-way terminal block is mounted on a 104 x 38mm piece of blank PCB material. Note that an earth wire must be soldered to the copper on the underside of the PCB and connected to the earth screw terminal at far right.

Below: inside the loop termination box. Use cable glands and silicone to seal the cable-entry points, to keep moisture out.

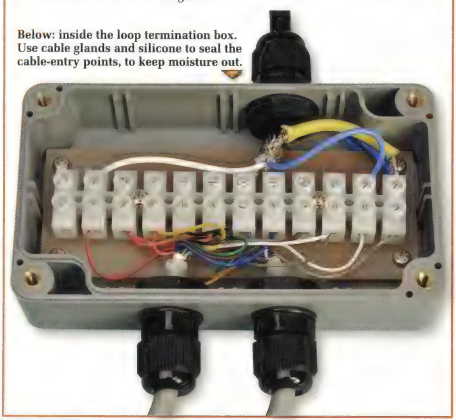


Fig.3 shows the parts layout on the PCB. Begin the assembly by fitting the five wire links (or 0Ω resistors) to the board (note: if you have a double-sided PCB, these links aren't required). The resistors can then be installed, taking care to install the correct value at each location.

Table 1 shows the resistor colour codes but you should also check each resistor using a DMM before installing it.

Follow with the non-polarised capacitors, then fit the polarised (electrolytic) capacitors. Make sure you fit the latter with the correct orientation, as shown on Fig.3. In particular, note that there are two different 47µF electrolytics. One is a low-leakage (RBLL) type and this goes in just below IC5. The other is a standard RB type and this is installed just to the right of REG1.

Now fit the five IC sockets, taking care to orientate their notched ends as shown on Fig.3. In particular, note that IC1 & IC2 face in the opposite direction to IC3, IC4 & IC5.

The diodes and transistors can now be installed. Be sure to orientate these parts correctly and take care not to get the transistors mixed up (Q3 is the BC337). Follow these with REG1, which is mounted horizontally at lower left. Its installed by first bending its leads down through 90° some 6mm from the device body. That done, it must be attached to the PCB using an M3 x 6mm machine screw, star lockwasher and nut before soldering its leads to their respective pads.

Next on the list are the three trimpots (VR1-VR3) and the piezo buzzer. Note that the PCB provides multiple mounting holes for the buzzer, to cope with different buzzer pin spacings.

Follow these parts with the 3-way SIL header strip for LK1, then install input socket CON1 and the 2.5mm DC power socket CON2. Make sure these parts are seated flush against the PCB before soldering their pins.

The two LEDs can now be installed. These must be orientated as shown (ie, with the longer anode lead to the top). They must also be stood off the board by 20mm. This can be done by pushing each LED down onto a 20mm-high cardboard spacer that's inserted between its leads before soldering the connections.

You can now complete the PCB assembly by plugging the five ICs into

their sockets. Be sure to install the correct IC at each location and make sure they are correctly orientated (IC1 & IC2 face in the opposite direction to IC3-IC5). Note also that IC3, IC4 & IC5 are all CMOS types, so take the usual precautions to minimise the risk of electrostatic damage. If possible, earth yourself before picking them up and avoid touching their pins.

The Driveway Sentry's PCB assembly is now ready for testing.

Test and set-up

For the initial testing, there's no need to connect the remote sensor loop to the PCB assembly. However, you will need to temporarily connect a 27Ω resistor between pins 1 and 3 of CON1 as a passive "stand in" (ie, between the two outer pins).

That done, connect a plugpack or another source of 12V DC to the DC input socket (CON2). If all is well, both LEDs should immediately light – LED1 to indicate that power is present and LED2 because the exit delay timing circuit has begun counting.

LED2 should now remain on for about two minutes after power-up. Similarly, it should also light and remain on for about two minutes after you press button S2.

Next, set trimpot VR3 to about midrange and check that link LK1 is in the "buzzer" position. Now wait until LED2 goes out, showing that the exit delay circuit has timed out, then press TEST button S1. The piezo buzzer should immediately sound for about 10 seconds.

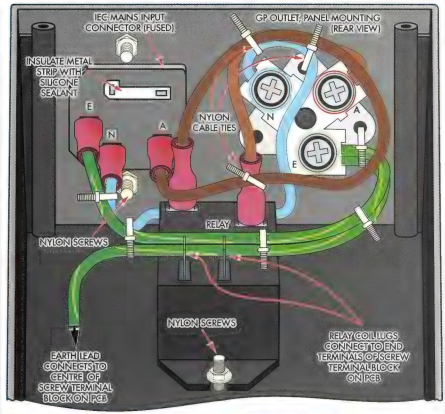
If the buzzer operating time is not to your liking (ie, it's too short or too long), this can be easily changed by adjusting trimpot VR3. The adjustment range is from about 2s up to about 25s.

The only other adjustment to be made to the Driveway Sentry is to vary the sensitivity of the sensor loop. This is done by adjusting trimpots VR1 and (if necessary) VR2 after the system has been installed and the remote sensor loop connected.

For the present, set VR1 fully anticlockwise and VR2 to midrange.

Making the sensor loop

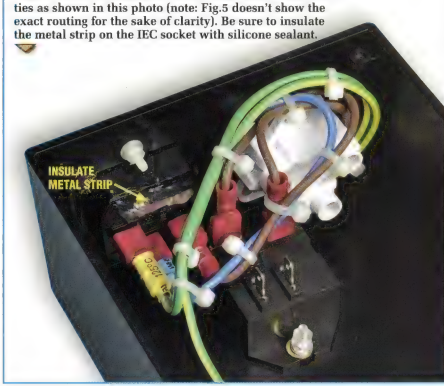
As mentioned earlier, the sensor loop consists of a 25m-length of screened 9-conductor "computer" cable, with the individual conductors connected in series to form multiple turns. The free ends of this multi-turn loop are then



(1) INSULATE METAL STRIP ON IEC SOCKET WITH NEUTRAL-CURE SILICONE SEALANT
(2) SECURE IEC SOCKET & RELAY TO CASE WITH NYLON SCREWS, NUTS & WASHERS
(3) COVER MAINS WIRING WITH PRESSPAHN INSULATION

Fig.5: install the mains wiring as shown here. Be sure to use mains-rated cable for these connections and make sure that all connections are securely crimped. The wires must also be routed and strapped to the tabs on the mains outlet socket using cable ties as shown in the photo below, so that it's impossible for a wire to come adrift and contact other wiring.

Below: route the mains wires and secure them with cable ties as shown in this photo (note: Fig.5 doesn't show the exact routing for the sake of clarity). Be sure to insulate the metal strip on the IEC socket with silicone sealant.



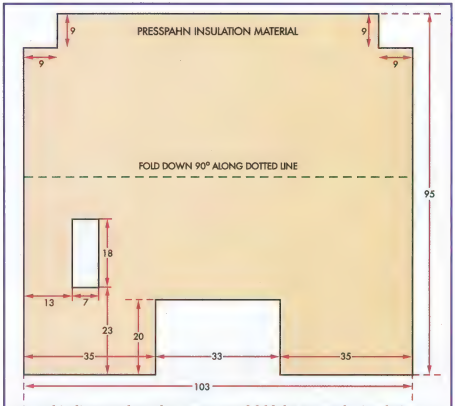


Fig.6: this diagram shows how cut out and fold the Presspahn insulation material that's used to cover the mains wiring. Don't leave it out – it isolates the mains wiring from the parts on the PCB.

The Presspahn cover has a cut-out to clear the relay and is fitted in position as shown here.

connected to a length of screened two-core extension cable which connects to the main unit.

In addition, one end of the loop cable screen (ie, the braid) is connected to the screen of the extension cable, so that the Faraday shield can work correctly.

This is all achieved by bringing both ends of the loop cable and one end of the extension (or output) cable into a small IP65 enclosure, dubbed the "loop termination box". This enclosure measures 115 x 65 x 40mm and houses a small blank PCB fitted with a 12-way terminal block to facilitate the various connections.

Fig.4 shows assembly details for the loop termination box. As you can see, it's really very simple, with the PCB supporting the 12-way terminal block for the necessary interconnections. The copper under the PCB is connected to the cable screens (at terminal 12), to provide a measure of screening inside the box.

All three cable ends are brought into the box via cable glands, with the two loop cable ends entering on one side and the output cable end entering on the opposite side. A Nylon cable tie is fitted tightly around each cable just after it emerges from its gland, as an added precaution against the cable being pulled out accidentally.

Having stripped and secured the cables to the box, it's just a matter of wiring their leads to the screw terminal block as shown in Fig.4. The wires at the "start" end of the loop cable are connected in turn to screw terminals 2-10 on the PCB, while the "finish" ends are connected to terminals 3-11.

That way, the conductors end up connected in series, to form a 9-turn loop with its overall start at terminal 2 and its finish at terminal 11. This means that the two inner conductors of the output cable must also be connected to terminals 2 and 11, as shown.

You need to take special care with the shielding wires and braids, to ensure correct operation of the Faraday shield. Make sure that the loop cable's shield wire at the "finish" end only is connected to screw terminal 12. The shield braid of the output cable is connected to the same terminal. In addition, a separate lead (shown green) must be run from this terminal and soldered to the copper on the underside of the PCB.

By contrast, the loop cable's shield wire is cut short at the "start" end and is not connected to anything. It can be covered with a small piece of insulating tape if you wish, so that it cannot short against anything. Nothing is connected to screw terminal 1, which is just a spare connection.

Twist each pair of wires together before inserting them into the terminal block. For single wires, you will have to strip back a little more insulation, double the wire over and maybe add a little solder to make it thick enough to be gripped when the terminal screw is tightened.

Once it's all wired up, tighten the outer sleeve nuts of the cable glands to make the entry points watertight (add silicone sealant if necessary). The box

Use Double-Crimp Spade Connectors

Note that the spade connectors used to terminate the mains wiring must be double-crimp types. This means that the metal collar inside each connector extends almost back to the wire entry hole.

That way, both the bared wires and the insulation are crimped by the metal surround, to give better retention. Don't use single-crimp types which crimp the copper only, as the wire can more easily come loose.

lid can then be fitted, along with its neoprene gasket, and fastened in place using the screws supplied.

The only step remaining is to fit the other end of the output cable with a 5-pin DIN plug, to mate with input socket CON1 on the main Driveway Sentry PCB. Note that the two inner conductors must be soldered to pins 1 & 3 of the plug, while the screening braid goes to pin 2 (ie, the centre pin).

Preparing the case

The drilling details for the box and its lid are available in PDF format from the SILICON CHIP website. These should be downloaded and printed out, after which the individual sections can be cut out and used as drilling templates (they can be temporarily attached to the box/lid using sticky tape).

Most of the holes can be made by simply drilling and (if necessary) reaming them to size. Be sure to always use a small pilot drill to start the larger holes, to ensure drilling accuracy.

The two holes for the mains input and output connectors at the righthand end of the box are inevitably more complex. These are best made by first drilling a series of small holes around the inside perimeter of the area to be removed. The holes can then be joined using a handheld jigsaw, after which the centre pieces can be knocked out and the edges de-burred and filed to a smooth finish using needle files.

Mains wiring

The next step is to mount the relay inside the case, with its switched output lugs nearest the adjacent end and the coil terminals towards the middle. **It should be secured using M3 x 12mm Nylon screws, with metal flat and lock**

Driveway Sentry: Parts List

1 UB2 jiffy box, 197 x 113 x 63mm
1 PCB, code 03107121, 140 x 84mm
1 110 x 100mm piece of Presspahn insulation material
1 PCB-mount mini piezo buzzer
2 panel-mount SPST pushbutton switches
1 PCB-mount 5-pin DIN socket (CON1)
1 2.5mm concentric DC input connector (CON2)
1 3-way PCB terminal block (CON3)
1 panel-mount fused IEC male input connector
1 M205 10A fuse
1 GPO mains outlet, flush panel mounting
1 12V SPST 20A chassis-mount mains relay (Ocean Controls RLY-008)
2 8-pin DIL IC sockets
2 14-pin DIL IC sockets
1 16-pin DIL IC socket
5 6.3mm fully-insulated female spade connectors (see text)
2 fully-insulated 4.8mm female spade connectors
1 150mm length of blue insulated mains-rated wire
1 200mm length of brown insulated mains-rated wire
1 400mm length of green/yellow mains-rated wire
2 120mm lengths of insulated hook-up wire
4 M3 x 25mm tapped spacers
9 M3 x 6mm machine screws
4 M3 x 12mm Nylon screws
8 M3 Nylon nuts
1 M3 hex nut
7 M3 star lockwashers
4 M3 flat washers
1 500Ω multi-turn trimpot (VR1)
2 500kΩ horizontal trimpots (VR2,VR3)
12 small Nylon cable ties
1 150mm length tinned copper wire
1 3-way pin header
1 shorting link

Semiconductors

1 AD623 instrumentation amplifier (IC1)
1 LM324 quad op amp (IC2)
1 4011B quad CMOS NAND gate (IC3)
1 4060B CMOS counter (IC4)
1 7555 CMOS timer (IC5)
2 PN100 NPN transistors (Q1,Q2)
1 BC337 NPN transistor (Q3)
1 7806 6V positive regulator (REG1)
1 5mm LED, green (LED1)
1 5mm LED, red (LED2)
1 1N5819 Schottky diode (D1)
1 1N4004 1A diode (D2)
1 1N4148 100mA diode (D3)

Capacitors

1 1000μF 25V RB electrolytic
1 220μF 16V RB electrolytic
1 47μF 16V RB electrolytic
1 47μF 25V RBLL low-leakage electrolytic
1 10μF 16V RB electrolytic
1 1μF MMC
2 470nF MKT polyester
1 220nF MKT polyester
1 150nF MKT polyester
10 100nF MMC or MKT polyester
2 22nF MKT polyester or greencap
1 10nF MKT polyester or greencap

Resistors (0.25W 1%)

1 470kΩ	4 10kΩ
2 220kΩ	4 4.7kΩ
1 180kΩ	1 1.5kΩ
2 100kΩ	4 1kΩ
1 68kΩ	1 560Ω
1 47kΩ	1 470Ω
1 27kΩ	2 100Ω
1 22kΩ	

Sensor Loop Assembly

1 IP65 sealed ABS enclosure, 115 x 65 x 40mm
1 blank PCB (ie, copper on one side), 104 x 38mm
4 M3 x 6mm machine screws
1 12-way barrier screw terminal block, 96mm long (Altronics P2130A)
2 M3 x 15mm machine screws and nuts
3 cable glands (for 3-6.5mm cable)
3 Nylon cable ties
1 25m length of screened 9-conductor "computer cable" (Jaycar WB-1578)
1 10-30m length (to suit) of screened 2-conductor heavy duty microphone cable (Jaycar WB-1530)
1 5-pin DIN plug, line type
1 50mm-length spaghetti tubing

This is the completed loop termination box, together with the sensor loop cable (light grey) and the extension cable (black) that runs back to the main unit. Make sure that the box is properly sealed against moisture.

will be necessary to bend the leads from the terminal block straight up from the PCB so that they will clear the Presspahn cover. Make sure that the Presspahn cover is correctly positioned before securing the lid using the four small self-tapping screws supplied.

The Driveway Sentry Mk.2 in now complete and ready for installation and sensitivity adjustment. Both the sensitivity control (VR1) and the trigger sensitivity control (VR2) can be adjusted after the box is fully assembled, via small access holes (one in the lid and the other in the lefthand end of the case).

The same goes for the alarm duration trimpot (VR3).

Sensitivity adjustment

To test the unit, the sensor loop must initially be laid on top of the driveway and connected to the main unit. You're then ready to adjust the sensitivity. It's simply a matter of setting VR2 to midrange and adjusting trimpot VR1 clockwise to make the Driveway Sentry more sensitive, or anticlockwise to make it less sensitive.

This will have to be done on a trial and error basis, with a vehicle driven over the sensor loop after each adjustment. The best setting is where it reliably detects the smallest moving vehicle likely to enter or leave the driveway but don't make it more sensitive than necessary. If you simply adjust VR1 for maximum sensitivity (ie, fully clockwise), the unit may be prone to giving false alarms due to passing radio transmitters or mobile phones, or during electrical storms.

Note that the loop direction will affect the sensitivity. If you cannot get reliable triggering, reverse the loop by turning it over. This means that you must test the complete unit before burying the loop.

VR2, the trigger sensitivity adjustment, is basically a back-up and is normally left in the midrange position. It need only be moved from this position if you run out of range with VR1.

Sensor loop installation

The remote sensor loop can either be buried just under your driveway (eg, under pavers) or it can be installed in the expansion joints of a concrete driveway.

As shown in Fig.7, two of its opposite sides lie in the narrow gaps between the concrete driveway slabs, while the other two sides run alongside the enclosed slab on either side. The loop termination box can be located adjacent to one side, with the output cable running away to the main control box inside your house.

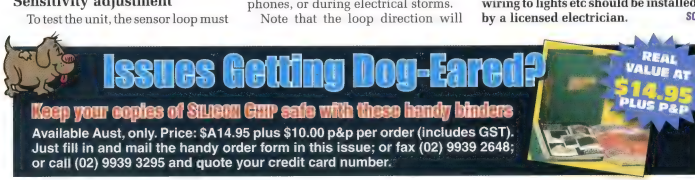
In practice, the loop termination box can be buried and the output cable run in a shallow trench back to the house, so that it doesn't get damaged. Make sure that the cable glands have all been properly sealed using silicone before burying the loop termination box, to prevent water damage.

If you are on a rural property, the loop sensor can simply be buried under the driveway in a shallow rectangular trench.

Using it

When the Driveway Sentry is armed and detects movement, it immediately produces an alarm sound from the buzzer and operates the relay. The relay contacts can be used to switch on a security floodlight, other lighting or perhaps a siren. The Alarm Duration can be set by adjusting VR3 using a screwdriver through the front-panel access hole.

Finally, note that any fixed mains wiring to lights etc should be installed by a licensed electrician. SC



Jaycar Electronics
Better, More Technical

AUGUST EDITION
Prices valid until 23/08/2012

HOT DEALS & BARGAINS

Economy 4 Channel DVR - D1 Resolution

Economical DVR for a home or small office. Features 4 channel multiplexer, Ethernet functions, and H.264 video compression. It also delivers D1 resolution video (704 x 576) at 100 frames per second. Playback can be displayed locally through the composite or VGA outputs and remotely via a network connection using a web browser or an iPhone®, iPad®, or Smartphone app*. Supplied with a 500GB HDD fitted, software and manual on CD, power supply, and quick start guide. See website for full specifications.

- Built-in web server for network access
- Power supply included
- Size: 375(W) x 285(D) x 45(H)mm

QV-8120

NEW $399.00

NOTE: *Remote access app available for iOS®, Android™ BlackBerry®, Symbian®, and Windows Mobile® operating systems. See our website for more information.

Also available: ***16 Channel DVR QV-8122 $899.00***

Soft Start Kit for Power Tools

Ref: SC Mag July 2012

Stops that dangerous kick-back when you first power up an electric saw, router or other mains-powered hand tool. This helps prevent damage to the job or yourself when kick-back torque jerks the power tool out of your hand. Kit supplied with PCB, silk screened case, 2m power cord and specified electronic components.

- 240VAC 10A
- PCB: 81 x 59mm

KC-5511

Due Early August

NEW $49.95

5.8GHz Wireless AV Transmitter and Receiver

Send AV signals around the house wirelessly without running wires. Great for transmitting Pay TV to another room. Exceptional performance and includes a built-in infrared extender so channel or volume can be changed remotely. It even handles the modern Pay TV remotes. Power supplies and AV cables included.

- 5.8GHz DIGITAL technology
- Expandable to multiple TVs using up to 4 receivers (sold separately)
- Range: up to 50 metres
- Works with Pay TV remotes
- Size: 150(L) x 112(W) x 110(H)mm (with antenna up)

AR-1878

NEW $99.00

Additional Receiver AR-1879 $69.00

Economy Non-Contact Thermometer

Safely measure temperature in hot, hazardous, or hard to reach places with the built-in laser pointer directed at the surface. Provides several readings within seconds. Compact and easy to use with carry case included.

- 8:1 Distance to spot ratio
- Auto Data Hold
- Temperature range: -30°C to +260°C
- Size: 131(H) x 96(W) x 35(D)mm

QM-7215

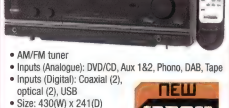
Colour may vary

NEW $49.95

200WRMS Per Channel Stereo Amplifier

HOT PRICE!

2 x 200WRMS channel stereo amplifier with remote control. Higher power and more features in a standard Hi-Fi component size.



- AM/FM tuner
- Inputs (Analogue): DVD/CD, Aux 1&2, Phono, DAB, Tape
- Inputs (Digital): Coaxial (2), optical (2), USB
- Size: 430(W) x 241(D) x 114(H)mm

AA-0484

NEW $329.00

PACKAGE DEAL!

DIY Package & SAVE $$$

Stainless Steel Side Cutters (TH-1890 $13.95)
32-pce Driver Set (TD-2106 $17.95)
Storage Case (HB-6302 $16.95)
Data-hold DMM with backlit (QM-1523 $14.95)

$49.95
SAVE $13.85

USB Power Bank with 2600mAh Battery

Features a USB charging port and lead with 3 connectors for charging all variety of Smartphones, tablets and USB charged devices. The device itself can be recharged with the supplied micro USB to USB cable.

NEW $34.95

- Output lead with 3 connectors included: Mini-USB, Micro-USB, Apple® compatible connector
- Size: 76(L) x 33(W) x 29(D)mm

MB-3642

NEW Store - Elizabeth
5A, 1 Philip Highway
SA 5112
Ph: (08) 8255 6999
Plenty of parking available!

USB Business Card Scanner

Save your business card contacts directly to an Outlook/Outlook Express address book. Using optical character recognition extract text from the business card and categorise it in to 13 different fields.

Laptop not included

- Scans single or double sided business cards
- Size: 120(L) x 70(W) x 20(D)mm

XC-4908 ***Was $79.95***

$59.95
SAVE $20

Network Connect Vandal Proof Mini Dome Camera 2MP

Access your CCTV system via the Internet or your local intranet. This dome camera connects straight to your existing network for complete control. Access the camera through a web interface by hitting the IP address of the device and logging in. The web interface allows you to control the camera around 3-axis, zoom, adjust visual settings, record, take snapshots and setup scheduled recording.

- Processor: TI DaVinci Series DSP
- Operating System: Embedded Linux
- Video compression: H.264/MJPEG
- CMOS camera sensor, 12VDC, PoE
- Size: 110(Dia.) x 54(H)mm

QC-8626

NEW $299.00

Water Powered Vehicle Kit

Build up to 13 different water powered vehicles and watch them move! This kit demonstrates water jet power and hydro pneumatic power in a fun and simple way.

NEW $39.95

- Suitable for ages 8+
- Assembly time: 30min approx.
- Size: 370(W) x 290(H) x 80(D)mm

KJ-8913

Inline JST Switch Kit

Includes a JST switch with a male and female JST connector on each end attached to a 140mm wire.

- Includes mounting bracket and screws
- Switch size: 25(L) x 23(H) x 9(D)mm

SS-0826

NEW $3.95

Chassis Mount Solid State Relays

40A 240VAC Triac Type

This unit has a dielectrically isolated DC control input that controls a 40amp TRIAC. This means that you can control AC mains up to 40A. It will not control DC.

SY-4084

100A 0-30VDC MOSFET Type

This unit has a dielectrically isolated DC control input to switch a MOSFET which can control loads of up to 100A @ 30VDC. It will not switch AC.

SY-4086

Also available: *Heatsink to suit SY-4085 NEW $9.95*

$47.95 ea

4 Gauge OFC Super High Current Cable

Run from your battery to distribute boxes and then 8GA to amps etc.

$6.90 mt SAVE $2

- Roll length: 50m
- Sold per metre

RED WH-3064
BLACK WH-3066

Sold per metre

Was $8.90

0 Gauge OFC Ultra High Current Cable

Run from battery to distribution blocks and then 2GA, 4GA or 6GA to your amplifiers or other power equipment for seriously high current applications.

$14.50 mt SAVE $5

- Roll length: 25m
- Sold per metre

RED WH-3092
BLACK WH-3094

Was $19.50

Adjustable Incandescent Lamp Flasher

This unit has 4 wires only: 2 to the mains and 2 to the lamp. Will electronically switch on/off from 0.6-9.0 secs adjustable, lamps from 15-300 watts, incandescent only.

$24.95 SAVE $5

- External fuse & suppressor capacitor required use RG-5240 $2.95
- Size: 70(L) x 50(W) x 40(H)mm with surface mount lugs

AA-0242 *Was $29.95*

Fixed Incandescent Lamp Flasher

When connected in series within a 240V incandescent lamp (up to 600W) the lamp will turn off and on (95% brightness) fairly slowly - about once a second approximately!

$19.95 SAVE $5

- External fuse & suppressor capacitor required - use **RG-5240** $2.95
- Size: 60(L) x 45(W) x 20(H)mm

AA-0214 *Was $24.95*

IR LED Receiver

TSOP4136 IR Receiver

Consists of PIN diode, pre-amplifier, AGC, pass filter, and demodulator. See website for datasheet.

- Supply voltage max: 6V

ZD-1953

NEW $2.25

Crystals

12MHz Crystal

- HL49U • 30 Ohm
- 11.5 x 4.65 x 13.5mm

RQ-5293

32.768kHz Crystal

- DT38 • 35 Ohm
- 3.1 x 8mm

RQ-5297

NEW $3.50 ea.

Stirling Engine Project Kit

See website for video online

A Stirling engine is a machine that converts heat into mechanical energy. The expanding air acts on a piston to provide mechanical force: you simply heat up the air chamber, give the flywheel a whirl and away it goes.

Made in Germany, our Stirling engine is beautifully engineered from stainless steel, brass and a genuine beech base. It has 2 ball bearings and should become an heirloom.

THIS IS A KIT, ASSEMBLY REQUIRED!

$219.00 SAVE $30

- Suitable for ages 12+
- Adult supervision recommended
- Size: 156(L) x 108(W) x 70(H)mm

YM-2923 *Was $249.00*

PIC30F2010 Microcontroller - DIP28

Digital Signal Controllers

- High performance enhanced flash digital signla controllers
- 16 bit architecture

See website for datasheet.

From $14.30

dsPIC30F2010 28-pin ZZ-8575 $14.30
dsPIC33FJ128GP802I/SP* 28-pin ZZ-8605 $14.95 NEW

RJ12 Extension Cables

- Colour Ivory

RJ12 6P/4C

- 1.0m YT-6042 $4.95
- 5.0m YT-6049 $7.95

RJ12 6P/6C

- 1.0m YT-6033 $9.95
- 5.0m YT-6034 $12.95

From $4.95

Right Angle Shaft Coupler (Male)

Basically a right-angle cast housing with 45° Nylon bevel gears permanently coupled. One shaft is enclosed with a panel-mount style threaded bush.

- Two mounting nuts and a lock washer are provided
- Nickel plated
- Each shaft is 10mm long

YG-2612 *Was $49.95*

$39.95 SAVE $10

Double -Stage Classic Style Universal Joint (Female)

- Works best between 80 and 45°
- Grub screws fixing 6.0mm diameter shafts

YG-2608 *Was $49.95*

$39.95 SAVE $10

All-Metal Universal Joint (Trunnion Style) Female 6.0 (Dia.)

This is a low torque coupler that will couple offset shafts by up to 2mm and 15 degrees off-angle. Accepts 6mm shafts with sleeved collet.

- Nickel plated

YG-2604 *Was $24.95*

$19.95 SAVE $5

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/08/2012.

18 Piece Stainless Steel Mixed Bit Set

A collection of commonly used driver bits in a handy rubber edged case. All stainless steel. Driver not included.

- Contains: Torx: T10, T15, T20, T25, T30, T40
  Flat blade: 3.5, 5.5, 6.5 Philips head: 1, 2, 2, 2, 3 Hex: 4, 5, 6
- Case size: 115(L) x 50(W) x 31(D)mm

TD-2111 ***Was $29.95***

$24.95 SAVE $5

9 Piece Folding Key Sets

Handy folding sets of Torx or Allen keys with sturdy anodised aluminium handles. The handles have M8, M10, E8 and E10 spanners built into them.

Buy ALL 3 for $12.00 SAVE $5.85

Torx Key Set
TD-2170 $5.95

Ball Allen Key Set Metric
TD-2172 $5.95

Ball Allen Key Set Imperial
TD-2174 $5.95

$5.95 Ea

IP67 True RMS Autoranging Cat IV DMM with Wireless USB

A quality true RMS multimeter with a wireless USB computer interface and includes logging software which allows computer based live data whilst keeping your computer completely isolated and protected. Double moulded housing and IP67 rated.

- Non-contact voltage indicator, data hold
- Backlit, auto off
- Diode test and audible continuity
- Cat IV, 600V, 4000 count
- 10A current range
- Size: 170(L) x 79(W) x 50(H)mm

QM-1571 ***Was $109.00***

$99.00 SAVE $10

Ethernet over Power - 200Mbps

A simple way to extend speedy wired networking around the house. The device will convert Ethernet packets from the Ethernet port to powerline communication packets (PLC packets), which run on regular home power lines, then converts them from PLC packets back to Ethernet packets.

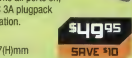
- Data rate: Up to 200Mbps
- Data link protocol: HomePlug AV
- Size: 115(L) x 59(W) x 26(H)mm

YN-8350

$129.00

10-Port USB Hub

Turn off non-essential peripherals while maintaining power to others with this 10 port USB hub. The two position switch turns all ports on, or only ports 7 - 10. 5VDC 3A plugpack required for powered operation.



- LED indicator
- Size: 172(L) x 36(W) x 27(H)mm

XC-4946 ***Was $59.95***

$49.95 SAVE $10

5W USB Soldering Iron

You wouldn't think USB could supply enough power for a usable soldering iron, but it works by using two USB ports and produces enough heat to be a viable service tool.

- Pocket-sized
- Power: 4 - 5W
- Size: 120(L)mm

TS-1537 ***Was $24.95***

$14.95 SAVE $10

Pocket Sized Non-Contact Digital Thermometer

Featuring an easy to read LCD. Handy for use in the kitchen or the food service industry to ensure proper cooking, grilling and storage temperatures.

- Pocket-sized with LCD
- Temp Range: -35 230°C / -31, 446°F
- Battery included
- Size: 74(L) x 40(W) x 20(D)mm

QM-7225 ***Was $34.95***

$29.95 SAVE $5

Precision Digital Vernier Calipers

Features a 5 digit LCD display that will show readings in metric and in imperial. The caliper can be zeroed at any point along the scale making comparative measurements easy. Battery included.

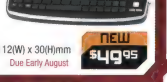
- Stainless steel
- Auto power off

TD-2082

$29.95

Mini Bluetooth® Keyboard

Make typing and navigation a breeze with our compact, wireless QWERTY keyboard. Use Bluetooth® to connect it to a wide variety of mobile phones, tablets, smart TVs, media centres or PCs. See website for more details



- Operation range: 10m
- Includes 2 x AAA batteries
- Size: 261(L) x 112(W) x 30(H)mm

XC-4945 Due Early August

NEW **$49.95**

USB Lead with 3.5mm Stereo Plug

Use the 3.5mm stereo plug to connect your iPhone®/iPod® to portable speakers or Hi-Fi system while charging via USB or mains adaptor (not supplied). Connect your device to the computer to sync with your personal iTunes® account. Avoid the mess caused by two separate cables.

- Cable length: 1.2m

WC-7695

NEW **$19.95**

Note: Laptop & iPhone® not included

Non-contact AC Voltage Detector

Detects AC voltages from 200 - 1000V. The unit will glow green when safe, and when voltage is detected it will flash red and beep at an increasing rate as you get closer to the voltage source. It can be used for detecting live mains in outlets, power boards or insulated wiring.

- Cat III rated
- LED flashlight function
- Size: 176(L) x 26(D)mm

QP-2268

NEW **$19.95**

4.8V Cordless Screwdriver

Easy to use, cordless and has a comfortable pistol grip that gives you maximum control. Also features a bright LED lamp, a magnetic bit holder, and a handy security strap.

- Voltage: 4.8V
- Bit holder size: 6.35mm
- LED battery level indicator
- Mains charger included

TD-2498

$19.95

FREE POUCH (TD-2499) valued at $5.95

PACKAGE DEAL!

DIY Package & SAVE $$$

Soldering iron starter Kit (TS-1651 $24.95)
32-piece driver set (TD-2106 $17.95)
Data-hold DMM with backlit (QM-1523 $14.95)
Tool set (TH-1812 $29.95)
Storage case (HB-6302 $16.95)

$79.95 SAVE $24.80

Universal Remote Control with Keyboard

An advanced learning universal remote control backed with full QWERTY keypad that also features optical finger navigation for mouse-like control. Perfect for media players, Smart TVs, home theatre PCs or gaming.

- Includes 2 x CR2025 batteries
- Size: 167(L) x51(W) x 15.3(D)mm

AR-1723

NEW **$34.95**

90W Universal Laptop Power Supply

An auto-switching laptop power supply with voltage regulation for added reliability. Features an LCD for voltage display and a USB port for charging your phone or MP3 player. Supplied with 11 different connectors.

- 90W output
- Size: 126(L) x 55(W) x 31(H)mm

MP-3326

Also available: ***90W Universal Slimline Laptop Power Supply MP-3327 $79.95***

NEW **$79.95**

iPhone®/iPod® Car Charger/Audio Kit

Modern in-car stereo systems support a 3.5mm audio-in socket to play music from popular, portable audio devices. Listen to your favourite songs from your iPhone®/iPod® using the integrated audio cable (with a 3.5mm stereo adaptor) while charging it via the supplied cigarette lighter adaptor.

- Lead length: 1.2m

MB-3653

NEW $29.95

Bluetooth® Handsfree Car Kit with LCD

Safely dial or answer a call hands-free whilst driving. Fits unobtrusively to the visor and features a large LCD screen to display incoming caller ID and the voice dial function. Connects up to two phones simultaneously and has a 360 hour standby between charges. USB cable & 12V car charger included.

- Noise, echo and wind suppression
- Size: 185(L) x 136(W) x 65(H)mm

AR-3122

NEW $59.95

150W Inverter with USB Outlet

This compact (150mm long) inverter plugs directly into your vehicle's cigarette lighter socket to deliver 230VAC at 150 watts. Comes with a USB port to charge or power your MP3 player or other USB operated device.

- Input voltage: 10 - 15VDC
- Output waveform: modified sine wave
- Size: 150(L) x 75(W) x 40(H)mm

MI-5125 ***Was $44.95***

$39.95 SAVE $5

Indoor/Outdoor Car Thermometer with Clock

Ideal for keeping track of the temperature when you're on the road. The unit plugs into the vehicle's cigarette lighter socket for power and also features an inbuilt clock.

- Input voltage: 12-24VDC
- Selectable blue or white LCD display
- Size: 86(L) x 34(H) x 21(W)mm

XC-0114

$19.95

FM Transmitter with Detachable MP3 Player - 2GB

Listen to your music on the MP3 player and when you jump in your car, keep on listening to that favourite track straight through the FM radio. Features a built-in MP3/WMA decoding chip that enables you to play from the stored TF card and built-in memory. Comes with USB charging cable and earphones. See website for specifications.

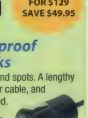
- 30mm LCD screen displays
- Operation voltage: 9V-26V
- Approx 230mm long (including MP3 player)

AR-3123

Detachable MP3

NEW $34.95

3.5" LCD Car Dash-Mount Colour Monitors



Mounts perfectly on your vehicles dashboard and when not needed, folds down into a compact shell for dust-protected storage. With two video inputs, the rear vision view is automatically activated when your reversing gear is engaged.

- Crisp high resolution display
- TFT active matrix system
- Auto switching PAL (4.43MHz) and NTSC (3.58MHz)
- Power: 12VDC 8W

QM-3771

BUY BOTH FOR $129 SAVE $49.95

$89.00

In-Dash MP3 Player with Radio

Listen to your favourite MP3s directly from the USB/SD card slot. Featuring PLL tuner with 18FM/12 AM presets, and MP3/WMA playback you will never miss a beat with this in-dash MP3 player.

- Front USB and SD card slot
- Max 16GB USB, 8GB SD (support HC cards)
- 4 channels x 40W MAX power output
- 4 channels x 20W RMS power output
- 2 channels x 2V line-out

QM-3781

$79.00

Flush Mount Mini Waterproof Camera for Cars or Trucks

Give drivers a clear view of car or truck blind spots. A lengthy 5m composite RCA cable, a 730mm power cable, and the appropriate sized hole saw are included.

- CMOS camera sensor

QC-3513

$89.95

Coaxial Car Speakers

Our ever popular Response Precision Kevlar Coaxial Speakers that has won many awards and magazine recommendations. The speaker cone is supplied in black and the soft dome tweeters provide clean, crisp sound and maintains a natural and smooth balanced sound.

4" 40WRMS CS-2400
WAS $69.95 NOW $59.95 SAVE $10.00

5" 50WRMS CS-2401
WAS $79.95 NOW $69.95 SAVE $10.00

6" 75WRMS CS-2402
WAS $89.95 NOW $79.95 SAVE $10.00

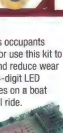
6 x 9" 75WRMS CS-2403
WAS $119.00 NOW $109.00 SAVE $10.00

From $59.95 SAVE $10

Sold as a pair!

Digital Tyre Pressure Gauge

Keep track of tyre pressure and avoid pressure related problems. Measures pressure from 5 to 100PSI and includes an integrated torch for night time use.



- Includes 2 x AAA batteries
- Size: 156mm long

QP-2293 ***Was $19.95***

$14.95 SAVE $5

12VDC Voltage Polarity Tester

A passive, quick and easy testing solution that performs five essential tests in the field: voltage, load, polarity, voltage drop and continuity. Ideal for CCTV and security installers, car audio, roadies, AV techs etc.

- Size: 51(L) x 44(W) x 29(H)mm

QP-2215 ***Was $24.95***

$19.95 SAVE $5

Economy Active 12" Subwoofer

This 12" Subwoofer in a sealed enclosure has a built-in amplifier to match. The unit produces a whopping 75WRMS of astounding bass. Equipped with line level and high level inputs, it also has built-in fuse protection and wired remote level control.

- Power output: 75WRMS
- Size: 425(W) x 355(H) x 360(D)mm

CS-2269

$99.00

G-Force Meter Kit

Measure the g-forces on your vehicle and it's occupants during your next lap around the race circuit, or use this kit to encourage smoother driving to save petrol and reduce wear & tear. Forces (+/- 2g) are displayed on the 4-digit LED display. Can also be use in measuring g-forces on a boat crashing over waves or on a theme park thrill ride. Kit includes PCB with pre-mounted SMD component, pre-programmed microcontroller and all onboard electronic components.

- Requires 2 x AA batteries
- PCB: 100(L) x 44(W)mm

KC-5504

NOTE: We supply the PCB with the SMD component already mounted on the board to save time and frustration.

Limited Stock. Not Available Online.

$49.95

Automotive LED Scrolling Message Sign

Attach this to the rear window of your car to display messages to other motorists. Taxi or bus drivers could use it to communicate vacancy or destination, emergency traffic control vehicles could communicate messages to slow down. Switch between pre-programmed messages easily with the supplied remote control and adjust the scrolling speed with ease.

XC-0201

NEW $49.95

Also available: *LED Scrolling Sign with Stand and Mains Adaptor XC-0202 $59.95*

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/08/2012.

OUTDOOR DEALS & BARGAINS

910 Lumen LED Powered Torch

An immensely powerful yet compact torch that uses a CREE® XM-L T6 LED for up to 910 Lumens of light output, making it ideal for heavy duty applications such as marine rescue, caving, or security. Supplied with batteries and mains battery charger.

- Light modes: high, medium, low, flashing, and SOS
- Burn time: 1.5 hours (max output)
- Size: 243(L) x 46(Dia.)mm

ST-3480

NEW $99.00

Replacement Li-ion batteries available
SB-2403 $19.95

Waterproof LED Spotlights

Suitable for lighting up walkways, water features, or general garden ambience. Fully waterproof with a pre-attached 4.5m power cable. Requires a 12VAC power source.

- IP68 rated
- Size: 50 (Dia). x 38(L)mm

1W 85 Lumens LED SL-2747 $19.95
3W 150 Lumens LED SL-2749 $29.95
Suitable power supply SL-2757 ***$14.95***

NEW From $19.95

Bicycle LED Indicator Kit

Keep your eyes on the road and turn safely using our bicycle indicator kit. Audible beeps confirm your choice of direction; one beep for a right turn and two beeps for a left turn. Has hazard light function for road-side emergencies.

- Super Bright
- Weatherproof
- Wireless; easy installation no messy cables
- Handlebar mounts with quick release
- Signal pod requires 3 x AAA batteries

ST-3227

NEW $29.95

Compact Fuel Cell Alcohol Tester

Provides far greater accuracy and reliability. Just blow in the mouthpiece for a reading in seconds. Same technology used by law enforcement for years. Spare mouthpieces available separately (QM-7303).

- Backlit LCD
- Alert at 0.05%
- Requires 3 x AAA batteries
- Size: 105(H) x 45(W) x 20(D)mm

QM-7302

$119.00

NOTE: Readings taken with this device are for reference only. In spite of its quality and accuracy, errors may occur due to operation or environmental conditions and we accept no liability or responsibility whatsoever for any consequences arising from the use of this device.

Includes FREE Spare Mouthpieces valued at $4.95

80Ch 0.5W Transceiver

This lightweight hand-held transceiver is suitable for professional and recreational activities such as hiking, boating, IT-cablers, electricians, inter-car road trip communication etc. Open field transmission range is up to 5km, with city range up to one kilometre.

- Green backlit LCD screen
- No licence required
- Requires 4 x AAA
- Size: 115(H) x 65(W) x 35(D)mm

DC-1021

NEW $49.95

Caravan/Marine Power System - 160W Solar

The perfect entry level power system for caravans and boats. Includes everything to make a complete 12V house battery system with enough stored battery power for short periods of free camping without AC power. Includes a Rich Electric CombiPlus 1500W-12V interactive inverter-charge, 2 x 80W mono crystalline solar panels, 150Ah AGM battery, dual battery isolator and most of the accessories required to round out the system. See our website for full details and performance.

MP-9011

$3890

Ask our staff for more CARAVAN/MARINE PACKAGES.

Keypad Shed Alarm

Simple and effective shed or garage alarm. Consists of a keypad, single reed switch and 5m of cable for easy DIY installation. Used as an instant alarm, with an entry delay or as a door chime to announce entry. Powered by a single 9V battery (not included).

- Size: 162(H) x 85(W) x 32(D)mm

LA-5214

$19.95

710 Lumen CREE® LED Powered Torch

Features silicone gasket sealed at both ends with a twist switch at the base to prevent accidental engagement. High quality rugged aluminium construction finished in gun metal matte grey/black. Ideal for outdoor activities.

- Light modes: off, high, low
- Burn time: 8 hours (3hrs on max setting)
- Requires 4 x D batteries
- Size: 355(L) x 52(Dia.)mm

ST-3451

$79.00

Solar Powered Garage LED Light

Ideal for garages, gazebos and greenhouses, the 360° adjustable solar panel will allow for custom positioning. Weatherproof and features a cord-switch to operate. Installation is simple.

- Solar panel size: 175(W) x 127(H) x 15(D)mm

SL-2715

DIY Package & SAVE $$$

$39.95

Buy both for $45 SAVE $14.90

Smart Solar Battery Charger

Supplies 15V at around 100-120mA of current which is enough to keep an unused 12V battery topped up. Housed in a plastic case, and has an output lead to cigarette lighter plug with a LED, which illuminates when the solar panel receives a charge.

- Size: 370(L) x 160(W) x 20(D)mm

MB-3501 ***Was $29.95***

$24.95 SAVE $5

Ultrasonic Antifouling Kit for Boats

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. By building it yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring. (Price includes epoxies).*

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- PCB size: 78 x 104mm

KC-5498

$249.00

Now available Pre-built:
Dual output, suitable for vessels upto 14m (45ft)
YS-5600 $899.00
Quad output, suitable for vessels upto 20m (65ft)
YS-5602 $1199.00

2kW & 3kW Petrol Generators

Petrol powered and differ from cheaper units due to the engine drives a DC alternator. The inverter then converts the DC to a stable pure sine wave 230VAC. The added benefit is that the petrol motor is far better matched to the load, reducing overall size, keeping engine speed in line with the load, reducing noise and increasing fuel efficiency. See website for full features and specs.

2kW MG-4502 $899.00
3kW MG-4504 $1499.00

From $899.00

NOTE: Not stocked in all stores but our staff can order them in for you.

MG-4504

MG-4502

Acoustic Guitar with USB Connection

Full size steel string acoustic guitar with laminated top and sides, built-in chromatic tuner and 3-band EQ. Suitable for all levels of users. Connect to a PC, play through an amplifier, mixing desk or PA. Easy to use recording and editing software included. Spare strings (pack 6) available separately (**CS-2558** $7.95).

- Windows & MAC® compatible
- Magix Music Maker
- Requires 1 x 9V battery

CS-2559

$189.00

Buy Both & Spare Strings for $290 SAVE $25.95

Portable Practice Amp

Feature packed with 32 built-in live rhythm drum patterns, volume, gain, distortion, overdrive and tone controls. AUX-IN jack to connect to CD/MP3 player and jam with your heroes.

- Headphone jack for private practice
- Built-in E-string tuner
- 2W Mono speaker
- Requires 1 x 9V battery for up to 8 hours play
- Size: 180(L) x 90(W) x 155(H)mm

CS-2553

$119.00

2.4GHz DIGITAL Wireless Speakers

Pop this pair of speakers in the backyard and the 2.4GHz DIGITAL audio transmitter will send crystal clear audio to the units up to 30m away. Each speaker has its own power adaptor and operates wirelessly. Power adaptor for transmitter and speakers are included, however speakers can also be powered via 6 x AA (not included) for complete portability.

- Speaker size: 250(H) x 130(Dia.)mm

AR-1891 ***Was $169.00***

$139.00 SAVE $30

3W CREE® LED Mini Spotlight

Ultra compact mini spotlights offering a super bright precision beam. Ideal for fixed lighting solutions and a range of party spot light applications to illuminate and decorate.

- Mountable and mains powered
- Size: 56(Dia.) x 97(L)mm

NEW $34.95 ea.

White LED SL-3470 $34.95
Blue LED SL-3471 $34.95

Music Centre with DAB+, USB & iPod® Dock

Enjoy crystal clear digital radio broadcasts, or listen to your MP3s directly from your SD card or USB memory stick. Charge your iPod® or iPhone® while listening to your daily podcasts, or load your CD and set your alarm so you'll awake the next morning to the sounds of your favourite playlist.

- DAB+ & FM digital radio tuner
- iPod® dock, USB port, SD/MMC card slot
- CD player, aux line-in
- Plays MP3, WMA, CD-R/RW
- Size: 310(W) x 115(H) x 185(D)mm

AR-1752

$149.00

iPhone® not included

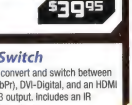
2 Input HDMI Switcher

Simultaneously connect 2 video sources to a single HDMI port on your display screen. Powered from the HDMI source it automatically switches to either port when a signal is present.

- Size: 80(L) x 43(W) x 15(H)mm

AC-1691

$39.95



HDMI 3-Port Switch

Allows you to hook up, convert and switch between a component video (YPbPr), DVI-Digital, and an HDMI signal to one HDMI v1.3 output. Includes an IR remote control and mains adaptor.

- Output: 1x HDMI v1.3 compliant output + optical SPDIF digital audio
- Power supply: 5VDC 2A included
- Size: 258(W) x 120(D) x 28(H)mm

AC-1684

$69.00

IR Extender Kit 2X

These IR emitter kits act like a hub, enabling you to interface all IR remote controlled devices together and control them from a single sensor point.

2-Way AR-1812 WAS $79.95 NOW $59.95 SAVE $20
6-Way AR-1814 WAS $99.00 NOW $79.00 SAVE $20

Additional emitters:
Single AR-1811 $7.95
Dual AR-1813 $9.95

From $59.95 SAVE $20

74 White LED Strobe Light

Features 74 super bright white LEDs with adjustable flash rate. Lightweight design made from a strong plastic and supplied with mounting hardware. Energy efficient and long lasting suitable home parties.

- Mains powered
- Size: 140(L) x 120(Dia.)mm

SL-3464

Due Early August

NEW $39.95

Active Noise Cancellation Headphones with Built-in USB Rechargeable Batteries

Suitable for frequent flyers and travellers, these active noise cancellation headphones will reduce background noise by up to 16dB. The ear cups rotate for compact size and easy storage inside your hand-carry bag or seat pocket.

- High quality digital stereo sound
- Built-in rechargeable battery
- Airplane adaptor

AA-2088

NEW $69.95

DMX Controller USB Interface

This kit controls DMX fixtures such as spotlights using a PC and USB interface. It can also be operated in stand-alone mode that outputs all 512 channels at the same time (9V battery required for stand-alone mode). Includes software, USB cable and enclosure.

- Test software and DMX Light Player software included
- 512 DMX channels with 256 levels each
- 3 pin XLR-DMX output connector
- Size: 106(L) x 100(W) x 44(H)mm

KV-3610 Limited stock. Not available online

$99.00

DMX Relay Control Kit

Control a relay with the DMX512 protocol. The relay will be activated when the DMX value of the set channel equals 140 or more and turns off when the value is 120 or less. Team it with KV-3610 to make a computer-controlled automation system. Short form kit.

- 512 unique addresses, DIP switch settable
- LED indication for power supply, relay output and error status
- Relay hold function in case of DMX signal loss

KV-3612

Limited stock. Not available online

$29.95

DMX Control Dimmer Kit

Allows you to control a lamp or group of lamps through a DMX signal. You can use the USB Controlled DMX interface kit or any other control console compliant with the DMX-512 protocol as a controller. It will drive resistive loads like incandescent lamps and mains voltage halogen lighting. Shortform kit.

- 512 unique addresses, selectable with DIP switch
- Status LED for power and error detection
- Size: 150(L) x 60(W) x 45(H)mm

KV-3614

Limited stock. Not Available online

$49.95

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/08/2012.

POWER CONTROL DEALS & BARGAINS

Mains Power Monitor with USB interface

Monitors the energy consumption of an entire home to determine how much electricity the appliances use. Displays power, cost, CO_2 and temperature.

- 433MHz wireless transmission up to 40m
- Includes 2 x D batteries for transmitter
- Display unit uses mains power or requires 3 x AAA batteries
- Max sensor current: 100A

MS-6165 ***Was $119.00***

$99.00 SAVE $20

Deluxe Mains Power Meter with CO_2 Measurement

This meter tells you the cost of electricity consumption of an appliance plugged into it and the amount of power used in kilowatt hours, as well as how many cumulative kg of CO_2 the appliance is putting into the atmosphere.

- Extra large LCD for easy reading
- Size: 120(L) x 58(W) x 40(H)mm

MS-6118

$29.95 Buy 2 for $50 SAVE $9.90

Smart Powerboard with Energy Meter

Easy to use and set up! Plug the main device e.g. a TV into the "smart" outlet, switch it off and all other plugged in devices will also turn off. The energy meter shows consumption in watts, cents per hour or CO_2 kg per hour.

- Surge protection, overload, spike and noise filtering
- Cord length 900mm
- Size: 385(L) x 60(W) x 30(D)mm

MS-6152

$59.95

4 Channel Single Blade RC Helicopter

This 4 channel helicopter allows a wider range of movement and has a built in gyroscope for stability. Equipped with 2.4GHz remote control for more responsive control. Recharged through the USB charger included.

- Built in Gyroscope
- Single blade
- 3.7V 150mAh Li-Po battery included
- 55 minutes recharge for about 7-10 min flight time
- Remote requires 6 x AA batteries
- Size: 240(L)mm
- Suitable for ages 14+

GT-3430

$69.95

60 Minute Fast Charger with USB Port

Recharge up to 4 x AA or AAA Ni-MH batteries fast. Delta -V controlled unit prevents over charging and the auto cut-off safety timer adds protection.

- 4 individual channels with LED indicators
- Charge current 2200mA for AA, 850mA for AAA
- Supplied with 240VAC adaptor & 12VDC adaptor
- Size: 114(L) x 75(W) x 30(D)mm

MB-3561

Batteries not included

NEW **$39.95**

Mains Standby Power Saver with IR Receiver

This energy saving device eliminates the standby power consumed by most modern appliances. Simply program the power saver with the standby level for your system and it will shut the power off whenever the set level is reached. Program any IR remote control to turn the power saver on again for simple and effective operation.

- Size: 128(H) x 65(W) x 40(D)mm

MS-6146 ***Was $29.95***

$24.95 SAVE $5

Wireless 3 Outlet Mains Controller

Simply plug in any mains appliance rated up to 10A and use the remote to turn each one on or off individually, or control all of them together. One of the outlets has an LED night light that's also operated with the remote.

- 433MHz
- Remote battery included
- Remote size: 125(W) x 45(H) x 17(D)mm

MS-6142 ***Was $44.95***

$34.95 SAVE $10

Spare Mains Outlet with Light
MS-6143 $17.95

Mains Outlet/Night-Light with Remote
MS-6145 $24.95

Digital Mains Timer Switch Modules

Ideal for automating your heating & lighting or practically any other switching application that requires multiple unattended switching cycles. The timer has eight on/off settings that can be programmed to function on any day, or combinations of days across the week.

$39.95 ea SAVE $10

12VDC Supply, Switches 16A@240VAC SPDT
AA-0361 WAS $49.95 NOW $39.95 SAVE $10

240VAC Supply, Switches 30A @ 240VAC 5PST
AA-0362 WAS $49.95 NOW $39.95 SAVE $10

Fluorescent Tube Adaptors T5-T8

Easily convert traditional T8 fluorescent lighting to more energy efficient T5 series tubes using these tube adaptor sets. T5 tubes output the same light level as standard T8 tubes while consuming up to 40% less power. Easy installation.

Light Energy Saving

Replaces 20W Tubes with 14W T5 Tubes
SL-2746 $17.95

Replaces 40W Tubes with 28W T5 Tubes
SL-2748 $19.95

NOTE: Not suitable in T8 fittings with electronic ballasts.

NEW From **$17.95**

Recreational Solar Panel Package

80W Standard Recreational Solar Package

Clean renewable energy wherever you go. Solar-convert your 4WD or caravan to generate sufficient power to operate several appliances - including your laptop, portable lighting, CB radio and 12-24V camping electricals. Just add a battery for your own self-sustained solar powered setup.

- Package includes: monocrystalline solar panel, charge controller, 2 x male and female PV connectors

ZM-9300

$300.00

DIY Package & SAVE $$$

Ask our staff for more SOLAR PACKAGES to suit your needs

Mains Timer with LCD

Control lighting or powered appliances with this programmable timer.

- 8 on/off programmes across 16 combinations of days or blocks of days
- Internal battery backup
- Rated up to 10A

MS-6110

$24.95

24 Hour Mechanical Mains Timer

Control any 240V mains appliance rated up to 10A. Simply rotate the dial to the time you want, then switch it on. Suits any 240V 10A GPO.

- Size: 120(H) x 76(W) x 50(D)mm

MS-6112

$9.95

Voltage Regulator Kit

Refer: Silicon Chip Magazine May 2007

This handy voltage regulator can provide up to 1,000mA at any voltage from 1.3 to 22VDC. Ideal for experimental projects or as a mini bench power supply. Kit supplied with PCB and all electronic components.

- PCB: 38 x 35mm

KC-5446

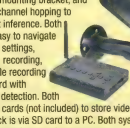
$16.95

SECURITY DEALS & BARGAINS

2.4GHz DIGITAL Wireless Mini DVR Kits

RECEIVE 50% OFF ON SPARE CAMERAS* WHEN PURCHASED WITH EITHER CAMERA/RECEIVER KIT

These mini DVR systems operate on the 2.4GHz DIGITAL band for stable, interference-free transmissions. Two models available, both include one colour outdoor day/night camera with motion sensor, a ball & socket mounting bracket, and utilise channel hopping to prevent inference. Both have easy to navigate system settings, manual recording, schedule recording or record with motion detection. Both use SD cards (not included) to store video and playback is via SD card to a PC. Both systems are expandable for up to four cameras.


QC-3630 shown

2.4GHz DIGITAL Wireless Receiver with Camera
QC-3630 WAS $199.00 NOW $179.00 SAVE $20.00

2.4GHz DIGITAL Wireless Display / Receiver with Camera and Integrated 7" LCD
QC-3632 WAS $279.00 NOW $259.00 SAVE $20.00

Additional cameras to suit:
Mains powered QC-3634 $139.00
Solar powered QC-3633 $189.00

Limited stock. Not available online

From $179.00 SAVE $20

Flush Mount Reed Switch Set for Timber Frames

Just drill a recess in your door or window and the magnet flush mounts to be "invisible". The reed switch segment is similarly mounted into the door frame or window frame & wired into your system.

Tapered version to suit Timber Frames
LA-5075 $4.95
Toothed version to suit Metal Frames
LA-5076 $5.95

NEW From $4.95

2.4GHz CCTV Wireless AV Sender

Wirelessly transmit high resolution D1 images (720 x 576) to a digital video recorder up to 300m away. Each unit features mounting holes for secure attachment, an antenna for each unit and a compact 9VDC power supply.

- FHSS mode up to 80 channels
- 9VDC power supply included
- Size (excluding antenna): 163(L) x 97(W) x 48(H)mm

QC-3201

NEW $199.00

10 Zone Alarm Kits

Fully configurable and programmable. Includes a central controller and the sensors you need to get a basic system up and running. Up to four remote keypads can be installed at up to 100m range and each can be named for easy identification.

- 10 programmable zones
- 4 access levels
- Walk test mode
- Events memory in keypads
- Programmable timers for entry, exit and alarm duration
- Kit includes: control panel, LED controller, PIR sensors, reed switch, bellbox, 50m 6 core cable and 12V 1.2Ah backup battery

LA-5560 ***Was $299.00***

$229.00 SAVE $70

Spare controllers and sensors also available:
LED Remote Controller LA-5561 $49.95
LCD Remote Controller LA-5563 $69.95
PIR Sensor LA-5564 $29.95

3.5" LCD Camera Kit

Connect power and install the camera where needed. The 3.5" TFT LCD gives real-time video monitoring and the microphone in the camera provides audio either through the speaker in the display unit or via headphone outlet. 20m power/video cable and mains plugpack included.

- IR illuminator
- CMOS sensor
- Size: 130(W) x 80(H) x 22(D)mm

QC-8007 ***Was $149.00***

Spare camera also available:
QC-8009 $69.00

$119.00 SAVE $30

Wireless Intercom Doorphone 2.4GHz

A compact doorphone using 2.4GHz DIGITAL transmission for crystal clear interference-free reception up to 100m range. Never miss anyone at the door with the portable receiver which can be taken anywhere around the house or even the garden. 240V mains charger included.

AM-4332

NEW $79.95

Digital Keypad with RFID Access Control

A single door multifunction standalone access controller or a Wiegand output keypad/card reader suitable for an area requiring stricter access control such as a laboratory, warehouse, bank, or prison. Housed in a sturdy zinc alloy casing and can support up to 2000 users. Full installation and wiring instructions in manual.

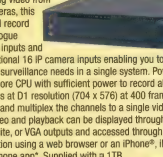
- 12VDC
- Waterproof
- LED indicator (green/yellow/red)
- Wiegand 26 input for connection of external reader

LA-5353

NEW $99.00

Professional 32 Channel Hybrid DVR

Capable of simultaneously recording video from 32 cameras, this DVR will record 16 analogue camera inputs and an additional 16 IP camera inputs enabling you to handle all your surveillance needs in a single system. Powered by a dual core CPU with sufficient power to record all 32 channels at D1 resolution (704 x 576) at 400 frames per second and multiplex the channels to a single video output. Live video and playback can be displayed through the HDMI, composite, or VGA outputs and accessed through a network connection using a web browser or an iPhone®, iPad®, or Smartphone app*. Supplied with a 1TB SATA HDD. See website for specifications.



- Size: 460(D) x 440(W) x 89(H)mm

QV-8124

NEW $1499

YOUR LOCAL JAYCAR STORE – Free Call Orders: 1800 022 888

• AUSTRALIAN CAPITAL TERRITORY

Belconnen	Ph (02) 6253 5700
Fyshwick	Ph (02) 6239 1801

• NEW SOUTH WALES

Albury	Ph (02) 6021 6788
Alexandria	Ph (02) 9699 4699
Bankstown	Ph (02) 9709 2822
Blacktown	Ph (02) 9678 9669
Bondi Junction	Ph (02) 9369 3899
Brookvale	Ph (02) 9905 4130
Campbelltown	Ph (02) 4620 7155
Castle Hill	Ph (02) 9634 4470
Coffs Harbour	Ph (02) 6651 5238
Croydon	Ph (02) 9799 0402
Erina	Ph (02) 4365 3433
Gore Hill	Ph (02) 9439 4799
Hornsby	Ph (02) 9476 6221
Liverpool	Ph (02) 9821 3100
Maitland	Ph (02) 4934 4911
Newcastle	Ph (02) 4965 3799
Penrith	Ph (02) 4721 8337
Port Macquarie	Ph (02) 6581 4476
Rydalmere	Ph (02) 8832 3120
Sydney City	Ph (02) 9267 1614
Taren Point	Ph (02) 9531 7033
Tuggerah	Ph (02) 4353 5016
Tweed Heads	Ph (07) 5524 6566
Wagga Wagga	Ph (02) 6931 9333
Wollongong	Ph (02) 4226 7089

• NORTHERN TERRITORY

Darwin	Ph (08) 8948 4043

• QUEENSLAND

Aspley	Ph (07) 3863 0099
Caboolture	Ph (07) 5432 2152
Cairns	Ph (07) 4041 6747
Capalaba	Ph (07) 3245 2014
Ipswich	Ph (07) 3282 5800
Labrador	Ph (07) 5537 4295
Mackay	Ph (07) 4953 0611
Maroochydore	Ph (07) 5479 3511
Mermaid Beach	Ph (07) 5526 6722
Nth Rockhampton	Ph (07) 4926 4155
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Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. **Prices valid from 24th July to 23rd August 2012.**

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PRODUCT SHOWCASE

New 11-input, 5-output Mixer from Altronics

Altronics Distributors have added to their already extensive range of Redback professional audio gear with this new comprehensively-equipped audio mixer, ideally suited to DJ and other pro audio work. A program cue selector allows a DJ to cue upcoming music tracks from any channel.

It can accept up to 11 input sources with a versatile selection: mono channels one and four accept either mic (6.35mm, 1.5mV) or line (RCA, 150mV) inputs; channels two and three are switchable stereo line or phono (3mV) via RCA sockets. Channel five is stereo line only, again via RCA sockets.

Somewhat surprisingly there is a lack XLR microphone sockets, apart from the DJs mic on the top panel (most "pro" mics use XLR connectors).

In keeping with the "DJ" use, the two phono inputs are for two magnetic cartridge turntable inputs – a significant proportion of DJs still prefer vinyl over CDs.

Each channel has a 3-band graphic equaliser and individual fader volume controls, plus crossfader assignment across all channels, which allows for fading from one music source to another without interruption.

The five outputs include master, zone and record outputs, all stereo, via RCA sockets, and two master (mono) balanced XLRs.

There's also a DJ headphone socket.

All this means it's not a small package: at 428 x 101(h) x 188 (d) and a 4kg weight, it's portable without being tiny.

The box includes a 9V AC/1500mA plugpack power supply and a quite comprehensive instruction manual with detailed setup diagrams and explanations.

All in all, it's a most comprehensive mixer and one that will be welcomed by professional and semi-professional audio operators.

It has a recommended retail price of $299 (Cat A 2554) and is available from all Altronics stores, resellers and via their website.

Contact:
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Electronex returns to Sydney

Electronex – the Electronics Design and Assembly Expo returns to Technology Park in Sydney from the 12 -13 September. The exhibition will be almost 50% larger than the inaugural expo in 2010.

The exhibition is open to engineers, production and purchasing staff involved in electronics design, assembly, manufacture and repair.

The SMCBA Conference will be held concurrently with the expo and will feature several international experts and cover a wide range of topics critical to successful design, assembly and test of electronics products and systems.

International presenters will include Gary Ferrari, Director of Technical Support for FTG Circuits, Dave Hillman who is with the Advanced Operations Engineering Department of Rockwell Collins and Craig Hillman, Director of DfR Solutions.

For further information and conference or visitor registration details please visit the show website www.electronex.com.au.

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SERVICEMAN'S LOG

Watchmaking is not really my forte

Dave Thompson*

Watchmaking is not exactly my forte but I'll take on just about anything these days to try to make a dollar. Sometimes my efforts are successful and sometimes they aren't but it doesn't hurt to at least try.

I've said it before and I'll say it again; in the current economic climate here in Christchurch, I'm prepared to have a look at anything that needs fixing, as long as the client is prepared to pay for my time. The other day, for example, I turned my hand to wristwatch repair although I have to say right up front that this type of work is not really my bag. However, someone asked if I could fix such things and since I am always a soft touch, I said I'd have a look.

Of course, if it had been a wind-up watch, I wouldn't have even bothered opening the back. Those types of watches are strictly for the professionals. And with new watches now selling for peanuts, it's seldom worth repairing run-of-the-mill watches anyway.

In this case, the watch apparently had sentimental value and after agreeing on a reasonable "dollar-cap", I got stuck into it. The problem with this 8-year-old ladies Casio quartz timepiece was that the hands had stopped moving. Usually, when something like that happens, the battery has gone flat and replacing it fixes the problem. However, when I pressed the illumination button on the side of the watch, the LED backlight told me that there was plenty of juice left in the battery.

~A DECENT HEAD MOUNTED MAGNIFIER IS ESSENTIAL FOR AN AGING SERVICEMAN

The first thing to really become apparent when I started working on the watch is that when it came to handling the tiny screws and other micro-fittings, I suddenly felt as if I had fingers of butter and fists of ham – and that's despite being able to handle surface-mount parts on PCBs. I also discovered that a decent head-mounted magnifier is essential for an aging serviceman to be able to even see what is going on. Fortunately, I have a set which I modified to use high-intensity LEDs instead of the old incandescent globes it used to have. Nothing beats good lighting when doing such fine work.

However, while my illuminated magnifier was a great start, my other tools fell short. All the screwdrivers, pliers and tweezers I normally work with were suddenly way too big and totally impractical for watch repair work. Even the smallest flat screwdriver in my set of so-called "jeweller's screwdrivers" was too fat for this watch's miniature screws.

However, I also have some ultra-small screwdrivers and tweezers, along with some other micro-tools, stored away from my aircraft engineering days. They've been sitting in a drawer, unused since my time in the instrument repair shop.

As it turned out, I didn't really need them because as soon as the watch's back was removed, the problem was obvious; a pale green "fuzz" coated the entire insides. This "fuzz" was mould, caused by moisture getting in, and it had wreaked havoc with the sensitive electronics and clockwork mechanisms.

It didn't take a crime-scene investigator to figure out why this had happened. A sorry-looking, chewed-up O-ring lay among the mould. This thin rubber seal is usually placed in a small notch cut around the outer edge of the housing at the back of the watch. When the back-plate is clipped in place, it slightly compresses the O-ring, sealing the interior from the elements and hopefully preventing moisture getting in.

In this case, the O-ring hadn't been seated properly and at some stage in the past, had been crushed and partially severed when the back had been pressed on following a recent battery change. As a result, there was virtually no seal at all.

At this point I knew it would be highly unlikely I could repair this watch, though I persevered out of interest. First, I removed three tiny screws that were holding a thin spring-plate to the rest of the movement. This was then eased clear of the movement and I could then actually see light reflecting off the moisture that had gathered underneath it.

The PCB, which occupied about a third of the room inside the case, was semi-circular in shape and contained several surface-mounted resistors and capacitors, along with other uniden-

Items Covered This Month

- Watchmaking is not my forte
- Buzzing recording studio
- Of mice & Triacs on a chook farm
- The spider & the Hereaus photo-polymiser machine
- Faulty LG dishwasher
- Soniq E19Z10A 48cm TV

*Dave Thompson, runs PC Anytime in Christchurch, NZ.

tifiable components. At one end, a tiny cylindrical crystal nestled into the movement's plastic moulding while at the other end sat a coil of ultra-fine wire. I assumed that both were part of the oscillator timing circuit.

Undoing two more tiny screws released the circuit board which I then carefully removed using tweezers. Like most modern circuit boards, it had been coated in a clear, hard lacquer but every exposed soldered or metallic area had still been significantly corroded.

When confronted with circuit boards like this, I usually break out my fibreglass PCB cleaning pen. This invaluable piece of workshop kit is like a wide-tipped marker pen but instead of having a solid felt ink dispenser, it has stiff, brush-like bristles made of strands of fibreglass. An adjustment wheel at the top end of the pen winds the bristles in or out of the barrel, to give a gentler or harsher action.

It's an excellent cleaning medium for stripping the likes of flux or even burnt fibreglass from a circuit board, or the aforementioned lacquer or corrosion. Anyway, I got stuck in but after cleaning the board, it was obvious that the prognosis was terminal. Even if I had the eyes of an eagle and a pin-sized soldering iron, I seriously doubted whether I could repair the tracks.

The only realistic option was replacement. I had a good look on Google, Casio's web site and the sites of various Chinese manufacturers to see if a spare movement was available. It was but as is always the way with spare parts, a new watch would cost far less than the spares, delivery and labour, no matter how cheap my time goes for these days.

In the end, I put it all back together and returned the watch to its owner, who now has it sitting in a drawer, not wanting to throw it away. I didn't have the heart to charge because I hadn't done anything other than confirm what I already suspected before I started the repair.

The moral of this story is that if the guy who replaced the battery a few months before had done his job properly, the watch would still be going. And it would have lasted many years longer, all for the sake of a 5-cent O-ring. Next time you get your watch battery changed, ask the salesperson to check the seal; it's well worth paying a bit extra to have it replaced.

The buzzing recording studio

For most musicians, a recording studio is a hallowed place. I'll never forget the first time I visited a real recording studio; I was 18 at the time and the sight of a 60-channel mixing console and racks of high-end audio-processing gear was enough to kindle a life-long love of such places.

So imagine my excitement when a new client wanted me to head over to his recording studio to show him a foot controller that I'd made. Like me, he'd been looking for a means of controlling his computerised Digital Audio Workstation (DAW) and through a mutual friend he'd heard I had recently made a wireless USB footswitch. I duly took it with me and as soon as he clapped eyes on it, he wanted one.

In the old days, analog multi-track recorders had remote switching capability, meaning transport

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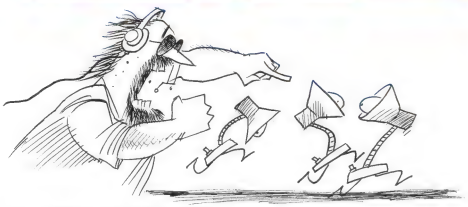
Serviceman's Log – *continued*



MY CLIENT RAN THE LAMPS FLAT OUT ALL THE TIME...

functions such as Stop, Play, Pause, Rewind, Forward and Record could be controlled either by switches mounted on the mixing console or by foot-switches placed underneath the workstation. Foot controllers are the obvious choice because they free up the hands and greatly improve workflow.

Of course, most modern studios do everything on computer these days and have done away with the old-style analog reel-to-reel recorders altogether. However, my new client's studio is set up to do both analog and digital 24-track recording, with the older systems maintained for those artists who prefer more retro sounds.

In this case though, something wasn't quite right because while I was demonstrating my footswitch to the client, I encountered something I consider sacrilegious in a recording studio – noise.

When the guy cranked up his monitor system, all I heard was an alarming buzz. Even when the song he'd loaded into his recording software to test the foot-controller started playing, there was an insidious buzz beneath the otherwise excellent audio fidelity.

Usually, engineers struggle to ensure that studio amplifier and speaker systems are as quiet as humanly possible. Having a buzz in the system is like a supermodel with missing front teeth; it just isn't right. I mentioned the noise to my friend and he said it was once as quiet as a mouse but had gotten worse in recent times but he didn't have the knowledge to track down the source. And he asked if I would like to have a go at fixing it.

Well, that's like asking a kid if he wants some lollies! I said I'd love to give it a shot.

I returned a few days later with my tools, a multimeter and my trusty signal injector. Anyone who has seen a recording studio of any size will know the cabling involved can be considerable. This studio was initially set up with an analog 24-track machine and later modified to include 24-track digital capability, with dozens of expensive and complicated-looking rack-mounted analog-to-digital converters, all with leads running in and out to a seriously large mixing console.

This all added up to many, many audio cables running in and out of the desk, effects chains, monitor amplifiers and speakers. In other words, the back-end looked like a rat's nest and I was beginning to regret being so hasty to offer to help out. Like many complicated systems, this had originally been nice and tidy but had then been added to piecemeal by various technicians and engineers, most of whom were no longer around. As a result, nobody now has any idea who did what and what goes where.

My first step was to try to isolate this buzz to one particular area. Was it originating in the mixing console? Or was it coming from somewhere in the monitor system? I unplugged the outputs (sends) from the mixing desk to the monitor amplifiers and plugged in a pair of headphones instead. The buzz was still there. That meant I could rule out the monitor system's amplifiers, leads and speakers.

Now all I had to do was try to find where it was being introduced into the desk. One way I could do this was remove every input lead while wearing the phones and see if that cured the buzz, so that's what I did. However, there was no change, even after every input had been isolated.

That meant bad news; the buzz was in the console so the next step was to isolate where in the desk the noise was coming from. Could it be something nearby superimposing mains hum into the system?

Most mixing consoles have rows of lights along the top, giving engineers the ability to kill the house lights and work in the mood-inspiring glow of the desk lamps. This console had a dozen small incandescent lamps mounted in gooseneck holders spread out over the length of the desk and these were on all the time, being powered on with the main desk power. There were six pairs of lamps controlled by six switches, which I turned off one by one. And when I switched off one pair, the buzz disappeared. Ahhah!

While my client ran the lamps flat out all the time, they could actually be dimmed by a knob on the desk. As a result, I suspected that this dimmer was faulty and was causing the noise. However, because this was all built into the console, I wasn't about to dive in and mess with it.

My client wasn't too bothered, claiming it was an old desk which was due for replacement soon anyway. In the meantime, he'd just stretch the lamps from either side to light the area

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in Silicon Chip? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Of Mice & Triacs On A Chook Farm

Servicing in rural areas can certainly throw up some interesting problems. M. G. of Christchurch, NZ has an interesting story about mice and Triacs . . .

Some years ago I received a call from a rural poultry farmer whose "laying house" lighting controller had failed. These controllers are designed to simulate sunrise and sunset and by cribbing a few hours each day, an extra day could effectively be added to the week (and thus make the chooks lay more eggs).

The fault, it turned out, was that the Triac had gone open-circuit (or maybe its gate had failed). However, because this part was buried deeply inside the works, it meant that the unit had to be taken back to the workshop to be repaired.

Once I had extracted the dead Triac and fitted a new higher-rated device, everything worked normally once more and so I returned to the farm and reinstalled the controller. There was an over-ride switch on the lighting circuit and this allowed the lights themselves to also be tested.

Not unexpectedly, the owner wanted to know what had caused the fault and as the unit had been running for about 10 years, I suggested the most probable cause was age related.

A week later, I received another call from the farmer, advising that the controller had just failed again. This time, however, the lights were staying fully on so obviously the replacement Triac had shorted out. Once again, I went out to the farm, collected the controller, returned it to the workshop, stripped it down and carried out the required repairs.

I then returned to the farm and reinstalled it. As before, the lights tested out OK and the insulation resistance was perfectly normal, so I simply put the Triac failure down to "infant mortality". And so, expecting that that would be the end of the matter, I returned to workshop with the profit margin on this job now looking decidedly lean.

What is it that they say about things happening in threes? Well, just 10 days later there was yet another call from a now somewhat irate farmer. The controller had failed yet again and as on the last occasion, the lights were fully on. And so once more, it was out to the farm to collect the controller, return to base, repair the unit, and then return to the farm to reinstall it.

While driving to and from the farm, I began to ponder what might be causing this problem. The replacement Triac was a 600V 16A device driving a circuit drawing slightly under 10A, whereas the original Triac was rated at just 400V 12A and it had lasted 10 years. In addition, the controller was a dimming type, so there was no inrush current as usually occurs with incandescent lamps. What's more, the insulation resistance was good and there were no shorted lamps.

So while I was installing the controller, I asked the farmer if he had noticed any unusual power fluctuations around the times of the failures. This area is notorious for power outages, as periodically Canada Geese and/or Black Swans have a bad habit of flying into the high-tension cables with fatal effect.

His answer was that nothing unusual had occurred but then, after a long pause, he said that over the past few weeks there had been quite a number of dead mice appearing on the floor in the No.3 shed. He went on to explain that they had not been using the No.3 shed for some time but had subsequently received a bigger shipment of hens than usual, so they had reinstated it.

Suspecting a clue, I asked him where in the shed the mice were appearing and he said just inside the entrance way. Ahhah! – the penny tumbled! I grabbed my steps and torch from the van and went down to the No.3 shed for a good look around.

The lighting cable path ran along the lintel at the top of the doorway and the cable used was the older TPS type. This is the type that rodents love to gnaw and in this case, they had really gone to town on the insulation, to the extent that the top half of all three conductors was completely exposed for the full width of the door lintel!

At the centre of the lintel there was a support that narrowed the path. As a result, any mouse traversing the lintel had to run on the exposed wires. It was sort of like Russian Roulette if the lights were on. Some made it, some didn't and eventually those who didn't make it blew the Triac.

The cable was replaced and a cover placed over it to prevent further rodent problems. After that, there were no more failures and the customer was happy.

the pair we turned off had covered. It was a simple fix and the studio monitor system is now as quiet as an empty church.

An itsy-bitsy spider

Spiders and other creepy-crawlies can cause all sorts of faults in electronic equipment. Here's one such story from I. R. of Alice Springs, NT . . .

I have been involved in the biomedical engineering field for about 25 years now. This is a diverse technical field supporting the medical profession and involves electronics, pneumatics, hydraulics, RF, lasers, robotics, nuclear medicine and various computer applications. So it's an interesting career to be in.

Working in a hospital in a remote outback town means that you get to be involved in all sorts of jobs, rather than just specialising in one specific area. For example, one day I got a call from the dental lab concerning an on-going intermittent fault in a Hereaus photo-polymeriser machine that's used to cure dental resins in mouth-guards and dentures. The fault was that, over the last few weeks, the unit had sometimes randomly stopped working with a lamp failure message and this problem had now become permanent.

This machine employs a high intensity xenon flash lamp which is very expensive to replace. When the fault originally started occurring, I thought that the problem was likely the lamp so one was placed on order. Because it's such a specialised lamp, it had to come from Germany which meant a delay in delivery.

FURTHER PROBING REMOVED THE SPIDER'S EGG SAC...

The problem was that, now that the machine had stopped completely, the lab technicians were forced to use an older curing unit which takes much longer than the Hereaus machine. This was a major inconvenience but eventually the new lamp arrived and was duly installed. Unfortunately, much to my dismay and embarrassment, the machine still refused to function – all this with the lab technicians looking on.

In short, there was no change in the machine's behaviour. The lamp would only fire briefly several times before the machine shut down with the same lamp failure message. After some poking around, I eventually decided to cart the heavy lump of expensive "junk" back to my workbench for a further look before contacting the support company.

By now, the pressure was on to get this machine going again. So in view of the lengthy downtime that would result if the unit had to be sent back to Germany, I decided to give the unit a detailed check-out for any obvious faults. Unfortunately, we didn't have any service documentation, so I was flying blind.

Initially, I figured that because the unit was trying to run on start-up (ie, with the lamp briefly firing), this meant that both the driver circuitry and lamp were OK. That in turn meant that the fault had to be with the monitoring circuitry.

As a result, I removed the lamp and its reflector to see if I could spot the monitoring set-up. When I did this, I immediately noticed a black tube with a sensor at one end. This sensor would send a signal to the processor to give the status of the lamp so I had a closer look at the lamp side of the tube and noticed some sort of white membrane covering the aperture.

I used a dental probe to carefully examine the membrane and then realised that it was a spider web! And when I removed the thick web cover, a very agitated spider raced out like a goanna with a tin can tied to his tail and disappeared into the mess on my workbench, never to be seen again!

Further probing removed the spider's egg sack and when I was satisfied that the sensor chamber was completely cleared, I refitted the lamp and tested the unit which now worked normally – much to my relief.

I figured that when the fault was originally intermittent, the spider had simply taken up residence in the case and when things got too hot, it hauled its hairy butt up into the sensor tube, thus causing the machine to stop after 20 minutes or so. Eventually, the spider figured that its temporary refuge would be a good place to make camp and that's when the fault became permanent.

Anyway, the dental technicians were very happy to have their polymeriser back and as for the spider, well she's completely disappeared.

Faulty LG dishwasher

Reader P. M. recently did battle with a client's dishwasher but the fault was quite a simple one. Here's how he tells it . . .

I have been repairing electronic and electrical equipment for many years and sometimes it's the simplest devices which cause the most angst. At other times, the fault is relatively straightforward to locate and fix.

I recently inspected an LG dishwasher which was playing up. The symptom was continued operation of the drain pump when any wash program was selected. The dishwasher would also sometimes display an "OE" fault code after 10 minutes of the pump cycling on and off.

Now most of the dishwashers I have repaired go through a cycle of emptying first before anything else is allowed to happen. And in this case, the owner's handbook described the fault as being a kinked or blocked drain hose.

Dishwashers are generally quite straightforward and faults can usually be diagnosed without circuit diagrams or other information. In this case, the unit was easy to dismantle to the point of accessing the pumps and solenoids underneath. That done, I began by checking for any obvious corrosion on the terminals and components, something that can be a problem with dishwashers.

In this case, everything appeared to be OK, and the unit could be run through its cycle quite safely. After watching many cycles and manually pouring water into the machine, the question became "how does it know when it's empty?"

The internet currently holds the answers to all the questions in the world, so this was now my starting point. A circuit diagram was easily found and this showed the wiring for the two pumps (wash pump and drain pump), the heater element and various control circuits. However, I still couldn't figure out what "tells" the controller that the water has all been drained.

Searching for the fault code revealed hundreds of other people have come across various error codes, the majority being caused by faulty pumps or broken wiring in the door. However,

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the pump in this machine worked well and the wiring was all intact.

Eventually, the penny dropped. The wiring diagram shows a microswitch connected in series with the heater element. And so, after exhausting many possibilities, this microswitch was removed for a closer look. This revealed that it was operated by a small diaphragm and it indicated when water was present in the heater chamber.

If the switch remains open, the controller assumes that water is still present in the machine. In this case, the microswitch was faulty and that was exactly what was happening. Replacing it fixed the problem, so it was an easy fix.

Soniq TV repair

TV sets are now so cheap that most smaller screen sizes are not worth repairing – unless you can get a friend to do it for nothing. J. W. of Hilary, WA recently did a friend a favour and found that although the fault was simple, there was a twist to the cure. Here's his story . . .

A friend recently asked me to have a look at his Soniq E19Z10A 48cm TV with DVD player which was just out of warranty. It wasn't worth taking to a repair shop, as he had paid just $150 for it.

I soon found that the separate 12V 4A switchmode supply was not working so if this was the only fault, the repair would be quite simple. A quick perusal of the Jaycar catalog showed that they had a 12V 5A unit (Cat. GH-1379) for $30, so I decided to use this as a replacement.

All I would have to do is change the connector going to the TV.

I duly purchased the power supply and made some temporary connections to make sure that all was OK before cutting off the connector. When I did this, I was surprised to discover that the TV would only turn on intermittently.

My first step was to check the output voltage from the new supply. This showed that it was dropping to about 11V. I could hear the relay in the TV trying to turn on but not quite making it. So was the TV trying to draw a large surge of current at switch-on, which was proving too much for the power supply?

I decided to risk it and pull the new power supply apart. My initial thought was that there might be a bad connection to the output but this wasn't the case. I then noticed that even when the TV was not connected, the voltage was regularly dropping to about 11V and then rising to 12V again.

At that point, the penny dropped – the power supply did not like running without a load and the regulation circuitry was constantly trying to pull the output voltage down. The TV wouldn't start when the output was at 11V but it would start OK if I happened to switch it on when the power supply was actually at 12V.

As a result, I experimented with various resistive loads until I found the lightest one that would keep the 12V constant without wasting too much power. Fortunately, the case had enough room for the 180Ω 2W resistor I used. And since I already had the supply apart, I swapped the output cable over from the defunct supply to produce a neat repair.

So a simple power supply replacement turned into an hour's work. Fortunately, when it was all back together, the TV then worked perfectly and my friend was happy to get it back for the cost of the new supply. SC

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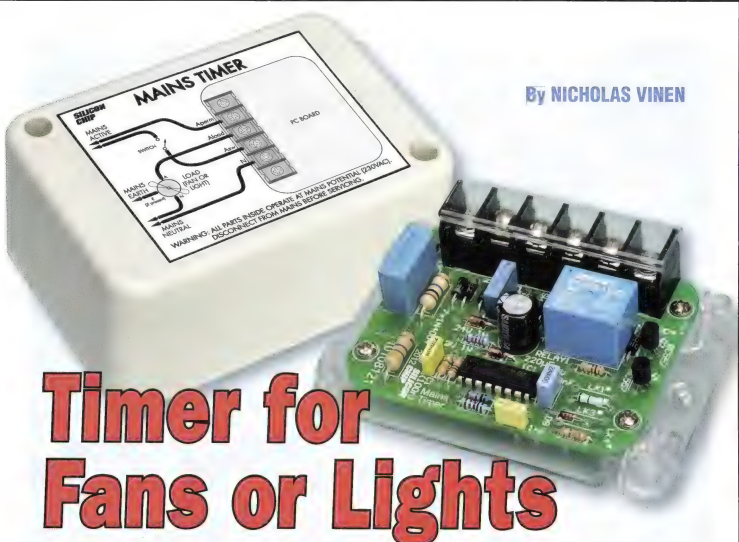
By NICHOLAS VINEN



Timer for Fans or Lights

This simple circuit provides a turn-off delay for a 230VAC light or a fan. It can be used to make a bathroom fan run for a set period after the switch has been turned off or it can be used with a pushbutton to turn a light on for a specific time. The timer circuit consumes no standby power when the load is off.

BATHROOMS AND toilets need an exhaust fan to vent humid air or odours outside. It's a good idea to have the fan running while you shower and then for a little while afterwards, to prevent condensation and mould. This unit makes it easy, by automatically running the fan for a preset period after the wall switch has been turned off and then switching itself off.

And while this timer was designed specifically with bathroom or toilet fans in mind, it is equally applicable to exhaust fans in kitchens where cooking odours need to vented outside. Of course, cooking also produces large amounts of water vapour so a fan is desirable to avoid condensation on the walls which can lead to mould.

It has other applications too. For example, many apartment buildings have lights in the foyer or stairwell with pushbuttons to turn them on. This allows people on any level to turn the lights on for long enough to get into or out of the building without the possibility of them being left on for long periods. This unit can perform that task too, when combined with mains-rated momentary pushbuttons or spring-loaded switches.

Or do you forget to turn off outdoor lights after visitors have departed? This timer will avoid that problem.

You can easily set the time-out from five seconds to one hour by changing an on-board link and possibly a capacitor. The whole thing fits in a standard junction box (Arlec 9071 or equivalent) for ease of installation. And as noted above, it has no standby power so it's quite "green" (well, the PCB is anyway).

Commercial units to do these jobs are available but can be hard to get and expensive. This SILICON CHIP design has relatively few parts and it can handle loads of up to 5A/1250VA.

Improvements

We published a similar mains timer

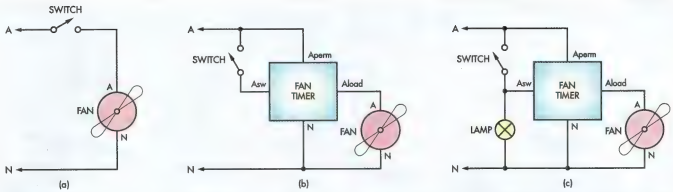


Fig.1(a) at left shows how a fan (or light) is normally connected, while Fig.1(b) shows how the wiring is changed so the Timer controls the fan, in conjunction with the switch. Fig.1(c) shows the circuit with the ceiling light in place, where the light and the fan share a common switch.

for fans in the October 2005 issue. That design used a PIC16F88 microcontroller and a Triac to control the fan. While it had some fancy features, its standby power was several watts which is something of a drawback these days. As well, its use of a Triac makes it incompatible with some compact fluorescent lamps (CFLs).

This new design dispenses with the need for a micro, so there is no need for programming. Instead, it is based on a cheap and commonly available CMOS oscillator/counter IC. There is no Triac either, as the load switching is done by a mains-rated relay.

Connections

The Mains Timer is designed to be added to an existing fan or light installation with minimal fuss. Fig.1(a) shows how a typical fan is wired up (this also applies to lights). The 3-core mains cable is normally run in the ceiling cavity with the Active line splitting out to run down to the power switch, mounted on the architrave or wall below. The switched Active line then runs back up into the ceiling to connect to the fan. Neutral and possibly Earth are permanently connected to it.

Fig.1(b) shows how the Mains Timer would be connected into the circuit. As before, Neutral and Earth wires run straight to the fan. The timer is connected in-line with the switched Active, with the wire from the switch going to its "Asw" terminal and the wire to the fan coming from its "Aload" terminal.

Two additional wires, "Aperm" and "N", are run back to the Active and Neutral supply. For the sake of convenience, the junction of the two Neutral lines may be made on the Mains Timer PCB if desired.

The additional Active line (Aperm) is necessary to power the fan or light after the mains switch has been turned off. The Neutral line is used to power the timer circuitry without affecting the voltage delivered to the load.

Finally, Fig.1(c) shows how you can add an exhaust fan to a room which only has a light switch, using the one switch to turn on the both the fan and the light. When the switch is turned off, the light goes off immediately but the fan runs for the preset time before it too goes off. All you have to do is run the switched Active line from the light to the Asw terminal on the timer and then run the Active, Neutral and load (fan) wires as shown.

Circuit description

Fig.2 is a simplified diagram of the Timer, showing how its power supply works. This configuration allows it to have zero standby power. Initially, the mains switch (S1) is off and so is

Warning!

This circuit is directly connected to the mains and all parts operate at 230VAC. As such, contact with ANY part of the circuit could be fatal!

DO NOT operate this circuit unless it is fully enclosed in the specified junction box and DO NOT touch any part of the circuit while it is connected to the mains.

Note that, in most states, a licensed electrician must be used to connect this unit to fixed electrical wiring.

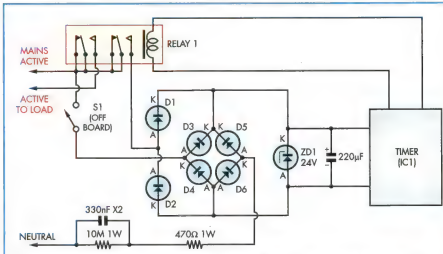


Fig.2: simplified circuit of the timer power supply. The mains is rectified by diodes D3-D6, filtered with a 220µF capacitor and regulated by 24V zener diode ZD1. A 220nF X2 capacitor in the Neutral leg limits the mains current. Diodes D1-D2 work in conjunction with Relay1 to supply power for the circuit after switch S1 is turned off, until the off-timer period expires.

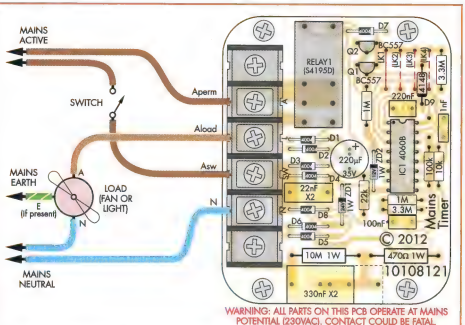


Fig.4: follow this layout and wiring diagram to assemble the timer board. Take care with the orientation of the diodes, the 220µF capacitor and IC1. Note that only one link (LK1-LK4) is installed, giving four time options (see text and panel for details on selecting the appropriate link).

The completed PCB fits into a junction box. It's shown here mounted on the base.

So if you swap the switch over to a momentary pushbutton and wire in the timer as shown above, the load will then turn on for the chosen period when the button is pressed and then automatically turn off again. The button can also be pressed any time the load is on, to reset the timer and keep it on for the preset period.

Construction

The Mains Timer is built on a PCB coded 10108121 (60 x 76mm). This fits in a standard junction box (eg, Arlec 9071). But note that not all junction boxes are the same and you will need to check that the one you are purchasing has mounting holes in the same positions as those of the PCB.

The PCB is available from the SILICON CHIP Partshop. While it is notionally a single-sided design, we have made it double-sided and added parallel tracks on the top to improve its mains current-carrying capability. In the absence of a kit being available, we recommend you build the timer using one of our boards since they have a solder mask which greatly reduces the chance of leakage paths developing and causing flash-over.

Referring to the PCB overlay diagram (Fig.4), start by installing all the small resistors. Use a DMM to check each as you go, since the colour codes can be hard to read accurately. The 0Ω resistor is used for one of LK1-LK4 and you must only install one of these. Refer to Table 1 and select your desired time-out, then fit the link (0Ω resistor or tinned copper wire) in the appropriate position.

Follow with the diodes, being careful with the orientation, and make sure the smaller 1N4148 diode goes in the top-right corner. **Note that the orientation of diodes D1-D6 and D8 alternates as you go down the board.** Install the two zener diodes (ZD1 & ZD2) also. These are in a larger glass-encapsulated package and both are orientated with the cathode stripe towards the top of the PCB.

Solder IC1 in place next, with the pin 1 notch or dot towards the top of the board as shown. Follow with the two 1W resistors – don't get them mixed up. You can then fit the smaller MKT capacitors. The 100nF capacitor can be a different value if you want to adjust the timing – see Table 1.

Now install the two transistors, bending their pins with a small pair of pliers to fit the pads provided. The flat faces are orientated as shown on the overlay diagram. You can then solder the electrolytic capacitor in place, with the longer (+) lead towards the top of the board.

Follow with the two X2 capacitors. Note that the larger X2 capacitor can have one of several lead pitches so multiple pads have been provided to suit them all; its left-most lead should go in the left-most hole provided and the other into the best fitting position. After that, solder the relay in place.

The terminal barrier is attached to the PCB using two 15mm M3 machine screws with a star washer under each screw head and nut. Check that the connector is straight and do the screws up tight before soldering the four pins. Use a hot iron to ensure that the solder joints form proper fillets.

Finally, attach the PCB to the junction box baseplate using four small

self-tapping screws and you are ready to test it.

Testing

If you have a bench supply and would like to test the PCB before it is installed and connected to the mains, you can do so. Connect a DC supply, set to slightly less than 24V, across ZD1, with the positive lead to its cathode (striped end). The circuit should draw about 30mA so if it draws much more than this, switch off and check for faults.

The relay may or may not switch on initially; if it does not, apply 24V to the SW terminal of CON1 and it should turn on. After the delay you have selected, it should turn off again. Assuming it does, the unit is working correctly and you can power it down. Otherwise, carefully check the component orientation, component values and solder joints.

Installation

Note that, in most states, this unit should be connected to the house wiring by a licensed electrician only. Note also that all parts on this circuit operate at mains potential (230VAC), so do not touch any part of the circuit when power is applied.

It's a matter of following the wiring diagram (Fig.4) to make the connections. You must switch off the circuit before you start working on it and check that it really is off before starting work.

Ensure that the junction box baseplate is securely anchored to a joist or ceiling batten using the supplied screws before doing the wiring. Note that you will need to knock out one or two panels in the junction box housing to allow the wiring to pass through.

The mains cables must be clipped or clamped to convenient beams or joists once you have finished. This keeps the ceiling space (or wherever the unit is installed) neat and prevents wires from being tripped over, accidentally yanked, etc. It also makes it easier to trace the wires to see where they go.

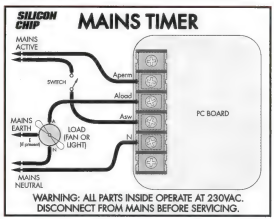


Fig.5: front panel label for the Mains Timer. Print this out, laminate it and glue it to the lid of the junction box (eg, using silicone sealant) for future reference.

In some cases, you may wish to use a single switch to control both a light and a fan – see Fig.1(c) for wiring details. Now, both the light and the fan will come on when the switch is turned on but when it is turned off, the light will go off immediately while the fan will continue to run for the programmed period before turning off.

If the fan has an existing earth connection, this should be left intact. Fans with a metal housing will tend to have an earth wire while those with a plastic housing may not. If the earth wire has to be cut, it can be re-joined using a double-screw BP connector.

Once everything is hooked up, check that all the terminal barrier screws are tight and there are no stray strands of copper from any of the wires that might short to something else. You can then clip the terminal barrier covering in place, fit the junction box cover, turn the power circuit back on and check that everything is working as expected.

Fans with 3-pin plugs

Many existing ceiling fans and all new fans these days come fitted with a lead complete with 3-pin mains plug. This simply plugs into an adjacent mains socket in the roof space.

In that case, a better idea may be to ditch the junction box and install the Mains Timer PCB in an IP65 sealed box. This can then be fitted with a socket, so that the fan can be plugged into it. We'll have more details on how to wire the unit up in this manner next month.

Short delay

Finally, note that in operation, you may notice a short delay between flicking the switch and the load coming on. This is usually only a couple of hundred milliseconds and is due to the power supply capacitors charging to the relay's operating voltage. It's short enough that it should not present a problem, especially when used with fans, which take some time to spin up anyway. SC

Table 3: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
330nF	0.33µF	330n	334
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
22nF	.022µF	22n	223
1nF	.001µF	1n	102

Table 2: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	2	3.3MΩ	orange orange green brown	orange orange black yellow brown
❑	2	1MΩ	brown black green brown	brown black black yellow brown
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	0Ω	single black stripe	single black stripe

By NICHOLAS VINEN

High-Current Adaptor For Scopes & DMMs

If you want to measure and monitor mains current of up to 30A using your DMM or scope, this is the safe and easy solution. It works just as well with DC and it has significantly better resolution and bandwidth than most clamp meters.

IN THE SILICON CHIP laboratory, we often need to hook our digital storage oscilloscope (DSO) up to mains-powered equipment to examine the current waveforms. The two most common ways to do this are with a shunt resistor and differential probe or a clamp meter. But both approaches have drawbacks.

A shunt resistor connected in series with one of the mains conductors (eg, Neutral) provides the best bandwidth and resolution but you need a differential probe (which can be expensive), even if you are measuring on the Neutral leg since Neutral is usually a few volts above or below Earth potential.

The resistor also limits how much current you can measure depending on its value. For example, a 0.1Ω 10W resistor limits you to measuring around 7A RMS (after de-rating by 50%). This option can also be quite unsafe as the wiring between the shunt and probe is connected directly to mains.

A clamp meter is safer since it doesn't require any exposed mains wiring. But they tend to have a fairly low output voltage, eg, 1mV/A. This gives you lousy resolution and noise performance with scopes which usually have a maximum sensitivity of 5mV/div. Clamp meters also typically have quite limited bandwidth (eg, 10kHz) which is no good for loads with fast-changing current waveforms such as switchmode supplies.

Also, you need to separate out the mains conductors to use a clamp meter since if you just clamp it over the cable, the Active and Neutral currents are of identical magnitude and opposite in direction so the magnetic fields effectively cancel. So you need some kind of special cable or adaptor to measure mains current with a clamp meter.

Our solution

With our adaptor, you get much higher bandwidth and resolution than a clamp meter (80kHz, 100mV/A) with better safety than a shunt resistor, no need for a differential probe and at a fairly low cost.

We use an Allegro ACS712 IC, which like a clamp meter operates on the Hall Effect principle but the whole shebang is within a single chip. One side of the IC contains a 1.2mΩ shunt which can handle a continuous current of at least 30A and pulses up to 100A for 100ms. On the other side is a fully isolated Hall Effect sensor and amplification circuitry.

There is no electrical connection between the two halves; sensing is

purely based on the magnetic field generated by current passing through the shunt. The chip has an isolation rating of 1500VAC between the two halves so the output can safely be hooked up to a scope or other device even if you are measuring mains current at up to 250VAC.

There are three versions of this IC, designed for sensing currents up to ±5A, ±20A and ±30A. They are otherwise identical. For our prototype, we used the 20A version since its output is 100mV/A and this makes it easy to set up our scope to read out directly in amps (by telling it we have a 10:1 current probe). We run it from a 5V supply, giving readings of up to ±25A although linearity is a little degraded at the extremes.

The 30A version has an output of 66mV/A and can read up to ±38A. You can use this one if you prefer but then you may need a calculator to interpret the readings.

Power comes from a 9V battery because this is much more convenient than a plugpack when setting up a test. We fitted ours with a mains plug and socket for measuring the current drawn by mains devices however it could also have been fitted with DC connectors if that's what we wanted to measure. The output is a BNC socket, making it easy to hook up to a scope. For connection to a DMM, we use a BNC plug to banana socket adaptor.

So that you can't accidentally leave the unit on and drain the battery (easy to do!), we incorporated an automatic time-out which switches the unit off after about 15 minutes. If you want to use it for a longer period, you just have to remember to periodically press the power button to keep it on.

Circuit description

Refer now to the circuit diagram in Fig.1. The power supply is shown at left while the actual current sense portion of the circuit is at lower right.

IC3 is the ACS712 shunt monitor IC. In addition to a 100nF power supply bypass capacitor, it has a 1nF filter capacitor from pin 6 to ground. This sets its bandwidth to 80kHz and provides a good compromise between bandwidth and residual noise. The shunt side of the IC, at left, is connected to two terminals of a 4-way terminal barrier, which is then wired to the mains plug and socket.

If you increase the value of the filter capacitor at pin 6, the residual noise is reduced but so is the bandwidth. For example, if you use 10nF instead of 1nF, bandwidth drops to 8kHz and noise to ~20mV (200mA) peak-to-peak. If you use 100nF then bandwidth drops to 1kHz and noise to ~10mV (100mA) peak-to-peak. If unsure, stick with the recommended value of 1nF.

IC3's output is at pin 7 and sits at half supply (about +2.5V) when there is no current flow. This is buffered by IC4a, half of an LM358 dual low-power op amp. Its is biased into Class-A operation with a 10kΩ resistor from its output pin 1 to ground (The LM358 data sheet explains why this is necessary). A 100Ω series resistor prevents instability that may occur due to output cable capacitance and the signal is available at the "+" output of CON2.

Ideally, we want 0V across CON2 when no current is flowing, rather than 2.5V, so we generate a half-supply rail at around +2.5V and connect that to the negative output terminal of CON2, so there is no voltage across it in the quiescent condition.

This is achieved using a voltage divider consisting of two 10kΩ resistors and 500Ω trimpot VR1. The voltage at

Specifications

Accuracy: approximately 2% error
Bandwidth: typically 80kHz
Range: ±25A* (linear over ±20A)
Output: 100mV/A*
Noise: ~40mV peak-to-peak (equivalent to ~400mA)
Power supply: 9V battery, approximately 20 hours life
Resistance: ~2mΩ plus cable resistance
Isolation: 2.1kV RMS (suitable for use up to 250V AC)
Withstand current: 100A for 100ms
Other features: power indicator, auto-off to preserve battery life
* With alternative shunt IC, range increases to ±38A (linear over ±33A) with 66mV/A output

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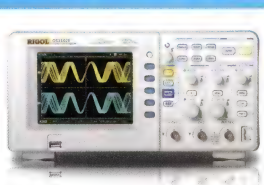

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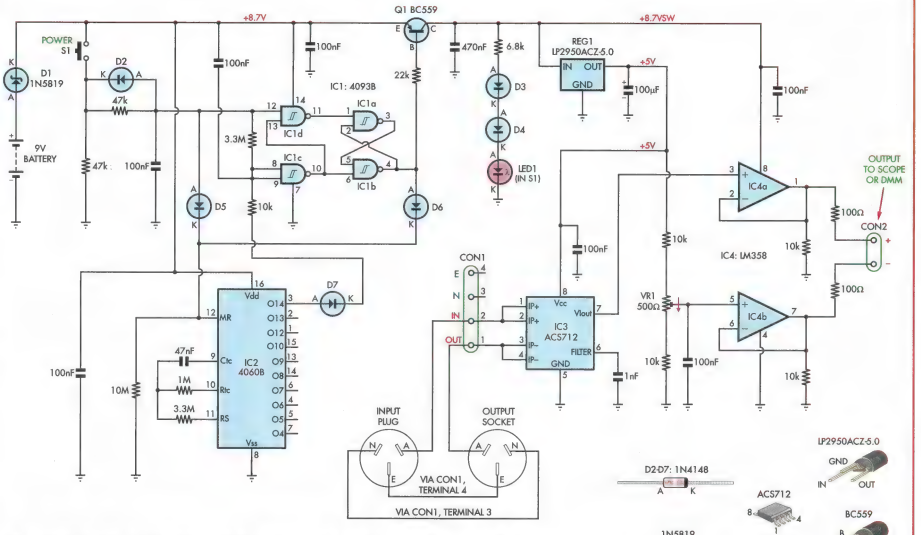


ISOLATED HIGH-CURRENT ADAPTOR FOR SCOPES & DMMs

Fig.1: the full circuit of the Current Adaptor. Connections are shown for measuring the mains current but it can also be used to measure low-voltage AC or DC current. Current flows through IC3's internal shunt and a proportional voltage appears at its VI_{out} terminal (pin 7). Op amp IC4 buffers this voltage and a half-supply rail to provide differential output voltages at CON2. IC3's 5V rail is derived from a 9V battery via low-dropout regulator REG1 and switched by transistor Q1, which is controlled by a flipflop formed by IC1a & IC1b. The unit is turned on by a short press from momentary pushbutton S1 and turned off by a long press or after 15 minutes by timer IC2. This prevents the battery from being discharged if the unit is accidentally left on; the timer can be reset with a brief press of S1.

Parts List: Isolated High-Current Adaptor

1 PCB, code 04108121, 60 x 107mm
1 UB3 jiffy box
1 right-angle PCB-mount tactile pushbutton with blue LED (S1) (Altronics S1181)
1 500Ω mini sealed horizontal trimpot
1 9V battery holder, PCB-mount
1 9V battery (alkaline or lithium recommended)
1 4-way PCB-mount (screw fix) terminal barrier (CON1) (Jaycar HM3162, Altronics P2103)
1 2-way polarised header, 2.54mm pitch (CON2)
1 2-way polarised header connector, 2.54mm pitch
1 female BNC panel-mount socket (Jaycar PS0658, Altronics P0516)
1 100mm length of light duty figure-8 cable or ribbon cable
3 M2 x 6mm machine screws
2 M3 x 15mm machine screws
4 M3 nuts
2 M3 flat washers
2 M3 star washers
2 M3 x 10mm tapped Nylon spacers
1 M3 x 15mm tapped Nylon spacer*
3 M3 x 6mm Nylon machine screws
1 sheet of Presspahn insulation, 70 x 30mm*
1 mains extension cord with moulded plug and in-line socket*
2 cord-grip grommets to suit 7.4-8.2mm cable (Jaycar HP0716, Altronics H4270)*
5 small cable ties*

Semiconductors

1 4093 CMOS quad Schmitt trigger NAND gate (IC1)
1 4060 CMOS oscillator/counter (IC2)
1 ACS712ELCTR-20A-T (Element14 1329624) OR
1 ACS712ELCTR-30A-T (Element14 1651975)
1 LM358 dual op amp (IC4)
1 BC559 PNP transistor (Q1)
1 LP2950CZ-5.0 low dropout, low quiescent current 5V regulator (REG1) (Jaycar ZV-1645, Element14 1262363)
1 1N5819 1A Schottky diode (D1)
6 1N4148 small signal diodes (D2-D7)

Capacitors

1 100µF 16V electrolytic
1 470nF MKT
7 100nF MKT
1 47nF MKT
1 1nF MKT

Resistors (0.25W, 1%)

1 10MΩ	1 22kΩ
1 3.3MΩ	5 10kΩ
1 1MΩ	1 6.8kΩ
2 47kΩ	2 100Ω

** For measuring mains current, substitute different parts for DC or low-voltage AC current measurement.*

Note: the PCB is available from the Silicon Chip Partshop.

VR1's wiper is filtered with a 100nF capacitor and buffered by op amp IC4b, the other half of the LM358. VR1 is adjusted so there is 0V across CON2 with no current through the shunt. CON2 is normally wired to a BNC socket with the negative pin side to its shell.

IC4, the LM358, runs off the +8.7V (nominal) switched rail from the battery so that both outputs have a full 0-5V swing. However, note that once the battery has dropped below 6.5V (when it's quite flat), the full swing may no longer be available. This could result in low readings towards the end of the battery's life.

To improve performance in this respect, an LMC6482 rail-to-rail op amp can be used in place of the LM358 and this will operate normally with a battery voltage down to 5V. However, the LMC6482 draws slightly more supply current; about 1.5mA compared to 0.5mA for the LM358, so the battery life will be slightly less.

Power supply

The ACS712 isolated shunt IC (IC3) runs from a regulated 5V rail, drawing about 10mA. This is controlled using momentary pushbutton S1 which also has an integrated blue LED. This LED lights up when the unit is on. When on, pressing S1 briefly resets the auto-off timer while holding it down for a second or two turns the unit off.

The power on/off control and auto-off timer functions are provided by IC1, a 4093B quad CMOS Schmitt trigger NAND gate IC and IC2, a 4060B CMOS oscillator/counter. Both these ICs are permanently powered by the battery but being static CMOS logic, only draw a tiny amount of current, typically <1µA. This is probably lower than the battery's self-discharge current so it will last many years with the unit switched off. Schottky diode D1 provides reverse polarity protection.

NAND gates IC1a and IC1b are configured as an RS-flipflop which controls power to IC3 and IC4. When the unit is off, output pin 3 of IC1a is low and output pin 4 of IC1b is high. Therefore, PNP transistor Q1 has no base drive and so no current can flow through its collector-emitter junction and into the rest of the circuit.

The high output from pin 4 in this state also forward biases diode D6, pulling pin 12 of IC2 (MR or master reset) high. This prevents IC2's oscillator from running, minimising its power consumption. Less than 1µA flows through the 10MΩ pull-down resistor.

When pushbutton S1 is pressed, two 47kΩ resistors, a 100nF capacitor and diode D2 provide a delay to debounce the switch. The delay is around 28ms, whether the button is being pressed or released. Because IC1d has Schmitt-trigger inputs (ie, inputs with hysteresis), the resulting slow rise and fall times are not an issue.

When S1 is pressed, input pin 12 of NAND gate IC2d goes high and assuming pin 13 is high (more on this later), its output pin 11 goes low. This sets the RS-flipflop, sending pin 3 high and pin 4 low, turning on Q1 and thus the rest of the circuit.

Pin 13 of IC1d is driven by IC1c. IC1c's inputs (pins 8 & 9) are tied together so that it operates as an inverter. It is fed from a further delayed version of the pushbutton signal; the 3.3MΩ resistor and 100nF capacitor form an additional low-pass filter which adds a delay of roughly two seconds. This means that the input to IC1c is still low when pin 12 of IC1d goes high; thus pin 13 of IC1d is also high.

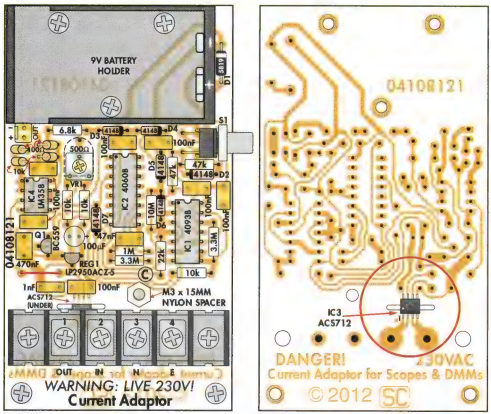


Fig.2: the PCB overlay diagram for the Current Adaptor. IC3, the ACS712 hall-effect shunt monitor is soldered to the underside as shown. A slot in the board prevents surface contamination from forming a leakage path between the high and low voltage sides of the IC. The current to be measured flows between the "IN" and "OUT" terminals of the terminal barrier at bottom and the output voltage appears across the 2-pin polarised header at upper left, just below the 9V battery holder. Pushbutton switch S1 at upper-right provides on/off control, timer reset and power indication via its in-built blue LED.

If S1 is held down, after this two second delay, the second 100nF capacitor charges up, bringing input pins 8 & 9 of IC1c high. IC1c's output therefore goes low. Since IC1c also drives an input of IC1d, IC1d's output simultaneously goes high. This condition, with input pin 6 of IC1b low and input pin 1 of IC1a high, resets the RS-flipflop, pulling the base of Q1 high and switching the unit off.

When pushbutton S1 is released, pin 12 of IC1d goes low before pins 8 and 9 of IC1c do, due to the different time constants of the two low-pass RC filters. This is important so that the unit stays off when S1 is released.

Auto-off timer

Alternatively, if pushbutton S1 is only pressed briefly while the unit is on, the 3.3MΩ/100nF RC filter does not have time to charge fully and so the unit does not switch off. But diode D5 will still become forward-biased and this pulls IC2's MR pin high, resetting the auto-off timer.

Once S1 has been pressed, the timer (IC2) runs for about 15 minutes and then switches the unit off. This time is set by the timing capacitor and resistor (47nF and 1MΩ), which give an oscillator frequency of around 8.5Hz. Output O14 (pin 3) goes high after 2^{13} = 8192 clocks and this gives 8192 ÷ 8.5Hz = 963 seconds or about 15 minutes.

When O14 goes high, this forward-biases diode D7 which charges the 100nF capacitor at pins 8 & 9 of IC1c via a 10kΩ resistor, resetting the RS-flipflop and switching the unit off.

Regulator

When Q1 is on, it supplies the ~8.7V from the battery to REG1, a low-dropout, low quiescent current 5V linear regulator. This draws less power from the battery than a 78L05 would and also allows the unit to continue operating down to a lower battery voltage.

The power LED integrated within S1 is powered from the 8.7V rail via two series 1N4148 diodes and a 6.8kΩ resistor to limit the current. The two diodes cause the LED to dim significantly as the battery voltage drops below about 6V, since the LED has a forward voltage of around 3.3V and the two diodes add another 1.2V to this. This gives a low battery indication before the voltage drops too low for the device to function.

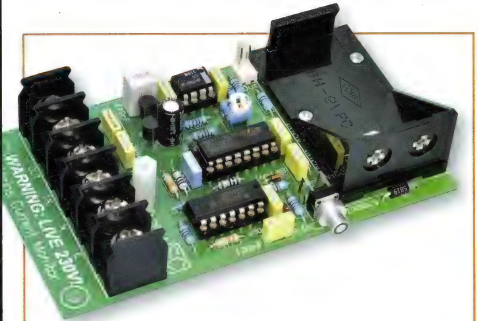
Construction

The unit is built on a PCB coded 04108121 and measuring 60 x 107mm. This is available from the SILICON CHIP Partshop. It's designed as a single-sided PCB with one wire link although we supply a double-sided PCB with that link already present (as a track on the top layer).

IC3, the ACS712, is a surface-mount device (SMD) in an SOIC-8 package and this goes on the underside. There is a slot down the middle of its mounting position, to maximise electrical isolation between the shunt and low-voltage sides. If you have made your own PCB, you should drill a series of 1.2mm holes between the IC pads where shown and file them into a slot.

The first job is to solder this IC in place. It must go in with its pin 1 (indicated with a divot, dot or bevelled edge) towards the bottom of the PCB, as shown in the PCB overlay diagram (Fig.2). The PCB indicates the correct orientation too.

Put a small amount of solder on one of the pads with the IC resting



The completed PCB, without the two corner mounting posts. We used IC sockets for our prototype but it's better to solder the ICs to the PCB so they can't come loose if the unit is dropped. Once the wires have been connected to the screw terminal block, the clear cover is clipped in place (not shown).

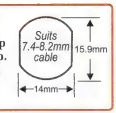


Fig.3: the correct cut-out to make sure the cord-grip grommets do grip. Don't be tempted to simply drill a 16mm hole!

alongside, heat the solder and slide the IC into place. If it isn't aligned properly on its pads, reheat the solder and nudge it. Repeat until it is correctly aligned, then solder the rest of the pins. Finally, re-solder the initial pin, to ensure the solder has flowed correctly, making a good joint.

Next, fit all the horizontally-mounted resistors, checking their values with a DMM. You can also refer to the resistor colour code table below. Follow with the diodes, being careful to orientate them as shown on the overlay diagram. Make sure that the larger Schottky diode (D1) goes at upper-right as shown.

Next, solder the DIP ICs in place. In each case, the pin 1 notch or dot goes towards the top of the board. Don't get the 4060 and 4093 mixed up as they have the same number of pins. **We recommend you solder them directly to the PCB so that they can't come loose and float around inside the box (rather than using sockets).**

Fit the MKT capacitors next. There are four different values and they go in the locations shown on the overlay diagram. Then mount transistor Q1 and regulator REG1 which are both in TO-92 plastic packages; check the markings so you don't get them mixed up. You can then install the single electrolytic capacitor (longer lead toward + symbol) and the polarised pin header, followed by the remaining resistors which go in vertically.

Trimpot VR1 can go in next, followed by pushbutton switch S1. You may need to bend the latter's leads slightly to get them to fit the holes as they are quite delicate and can easily be bent out of shape during transport. That done, use three short M2 machine screws to attach the battery holder to the board, then solder the leads.

That just leaves the terminal barrier, which is mounted using M3 screws with flat washers under the heads and star washers between the nuts and PCB. Do up the screws tight, check that it is parallel with the edge of the board and then solder the pins, using a hot iron and a generous amount of solder.

The PCB assembly can now be completed by attaching three tapped Nylon spacers. As shown in one of the photos, the two M3 x 10mm spacers are attached to the two corner holes adjacent to the terminal strip (ie, on the underside of the PCB) using M3 x 6mm Nylon screws.

The M3 x 15mm Nylon spacer goes on the top of the board as shown in Fig.2 and is also attached using an M3 x 6mm Nylon screw. It's used to help retain a Presspahn isolation barrier.

Testing

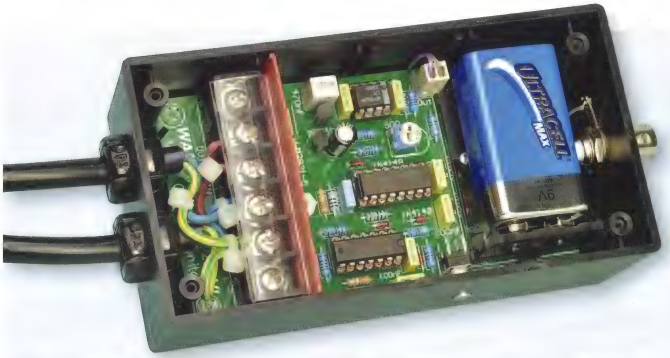
Check that the power supply works by connecting the battery and pressing the pushbutton. The blue LED should light up. Hold down the pushbutton for a couple of seconds and check that it goes off. Then set the trimpot to its mid-position, turn the unit back on and measure the voltage across the

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
470nF	0.47µF	470n	474
100nF	0.1µF	100n	104
47nF	.047µF	47n	473
1nF	.001µF	1n	102

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	1	3.3MΩ	orange orange green brown	orange orange black yellow brown
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	2	100Ω	brown black brown brown	brown black black black brown



The unit all wired up and ready to go. Note how the 2-wire ribbon cable for the output signal is clamped by the PCB. There isn't a lot of room for the output connector next to the battery so we had to trim its central solder pin. You can also see how the Presspahn cover is held in place by the plastic case slots, terminal block and tapped spacer.

polarised pin header. It should be less than ±250mV. Adjust it as close to zero as you can, using the trimpot, then switch it off again.

Preparing the case

The next step is to drill a 5mm-diameter hole in the side of the case for the on/off pushbutton. This hole is positioned 22mm down from the top lip of the case (ie, not including the lid) and 47.5mm from the output end (again as measured from the top lip).

You can then drop the PCB into the case at an angle, to check that the hole lines up correctly when the PCB snaps into place. If not, enlarge it slightly.

Two M3 x 10mm tapped Nylon spacers are fitted to one end of the PCB as supports.

Next, make the holes for the output socket(s). We simply drilled a 9mm diameter hole in the middle of the end for the panel-mount BNC socket but you could use a pair of binding posts if you want. Keep in mind that there is only about 11mm of clearance from the battery to the end of the case so whatever you use, it can't intrude very far. In fact, before installing the BNC socket, we had to cut off most of the central prong since it stuck out too far (you only need a short section to solder to).

Remove the PCB and fit the BNC socket. Crimp and solder a 70mm length of light-duty figure-8 cable to the two polarised header pins, then push the pins into the moulded plastic housing. Solder the other end of these leads to the rear of the BNC socket, with the lead from pin 1 on the polarised header (normally indicated on the plastic housing) going to the BNC shield while pin 2 goes to the central pin.

Mains leads

If you are not planning on using the adaptor with mains, you can use binding posts or whatever you prefer to make connections to the terminal barrier. However this section will describe the procedure for connecting mains cables.

The first step is to cut the extension lead in half. Strip away about 50mm of outer insulation from both ends and then expose 7-8mm of insulation from each Active and Neutral wire and 15-20mm for the Earth wires.

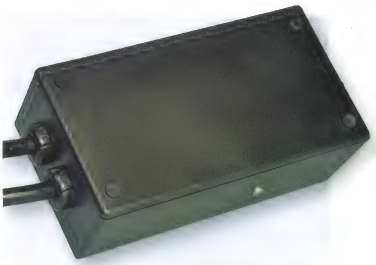
You will then need to make two holes in the case, at the opposite end to the BNC socket. These are spaced 25mm apart, on either side of the centre of that end and have a diameter of 14mm. Start with a smaller hole (4-5mm say) and then enlarge using a tapered reamer or stepped drill bit. Make sure you don't make the holes too large since the cordgrip grommets need to be a tight fit. **Then profile the holes to the shape shown in Fig.3, using a file. Again, be careful not to make the opening too large.**

Now place one of the mains leads through one of the cord-grip grommets, with the bare leads towards the narrower end. Squeeze the grommet together hard using large pliers (or if you're lucky enough to have one, a grommet insertion tool), so that only a short length of the cable's outer insulation protrudes from that narrow end.

Push the grommet into one of the holes and it should snap into place. If it won't go, enlarge the hole very slightly and then try again. Be careful since once it's in, it's very hard to get it out. Do the same with the other cable and grommet into the other hole.

Now check that the two mains cords

This close-up view shows how the Presspahn cover is held in place by the plastic case slots, the mains terminal block and the M3 x 15mm tapped spacer.



The completed unit with the lid in place. Note how the illuminated on/off pushbutton switch protrudes through a hole in one side of the case.

are securely anchored. You must not be able to pull the cords out of the case, even if you exert considerable force.

That done, connect the two Active wires to the terminals marked "IN" and "OUT" on the PCB. **For correct output polarity, "IN" should go to the plug and "OUT" to the socket (current flowing from IN to OUT will give a positive output voltage).** Do these up tightly, too.

Twist the two Neutral wires together and screw them down tightly to one of the spare the terminals on the PCB (see photo). Do the same for the Earth wires. Make sure both are secure. You can then use several small cable ties to hold the wiring in place. These must be installed to prevent individual leads from moving and contacting other wiring if they come loose.

Once these are in place, clip the clear cover on top of the screw terminal block.

Presspahn barrier

The next step is to fit a Presspahn insulation barrier between the mains terminal block and the low-voltage section of the PCB. **This insulation barrier is retained by the adjacent slots in the side of the case and must be trimmed to exactly 63 x 25mm so that it is a tight fit.**

As shown in the accompanying photo, this barrier is sandwiched between the screw terminal block and the adjacent M3 x 15mm Nylon spacer. If necessary, rotate the spacer slightly so that one of its lobes presses the Presspahn insulation firmly against the screw terminal block.

Do not leave the Presspahn barrier out – it makes it impossible for any of the mains wiring to contact the low-voltage section of the PCB and is an important safety measure.

Note that once the lid is in place, the Presspahn barrier is also clamped between the lid and the PCB.

Final assembly

Plug in the polarised header and put the lid on the box. Then use a DMM to make some checks before connecting the device up:

(1) Check that the Earth terminals on the mains plug and socket have a very low resistance between them (should read zero or very close to it).

(2) Do the same check between the Neutral terminals and then for Active.

(3) Check that there is no connection between all three pairs of terminals on the mains plug and then on the socket (ie, many megohms; meter should normally read "OL" or similar).

(4) Check that there is no connection between both terminals of the BNC socket and all the mains terminals; again, the meter should read "OL".

Now plug the unit into mains and, without touching anything, switch on and measure the AC voltage between the BNC shield and Earth using a DMM. It should be just a few volts. Do the same check with the BNC centre pin. Only when you have ensured that there is no mains voltage on these two conductors should you connect the BNC output to an oscilloscope.

You can then do a functional test by connecting an appliance with a known current to the output. For example, if you use a 1kW bar radiator, its current should be about 2.4A, depending on the actual value of the mains voltage. You can then monitor the current with a DMM or oscilloscope. Check that you get a sensible reading.

A BNC plug-to-banana socket adaptor can be fitted to the BNC output socket if you want to connect a DMM.

Assuming all is well, disconnect your test load and check the DC output level of the adaptor. It should be close to zero. If not, disconnect all mains cables, open the unit up, make sure it is switched on and adjust the trimpot again. We found that the offset changed slightly the first time we used the unit to measure a high current, so you need to do the final trimming at this stage to guarantee a low offset.

That's it; using the device is simply a matter of plugging it in and switching it on. Don't forget to periodically reset the timer if you are undertaking a long test or measurement session. SC

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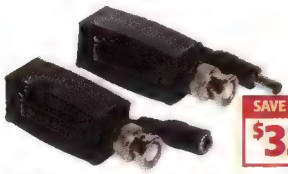

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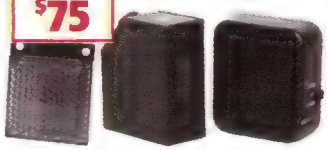

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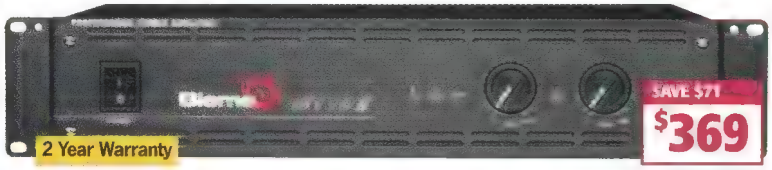

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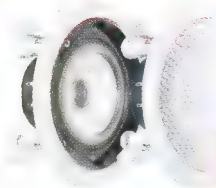

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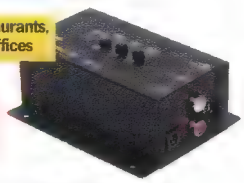

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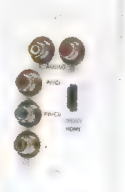

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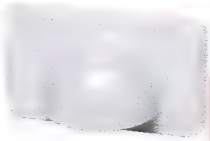

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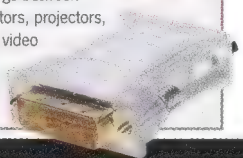

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B 6006

Pt.3: By JOHN CLARKE

Wideband Oxygen Sensor Controller Mk.2

In Pt.2 last month, we gave the full assembly details for our new Wideband Controller Mk.2 and its companion Display Unit. Our final article this month describes how the oxygen sensor is installed in a car and connected to the Wideband Controller.

AS MENTIONED in Pt.1, the Bosch LSU4.9 wideband sensor can be installed in the exhaust pipe by screwing it into a suitable threaded boss. This should be positioned as close to the engine as possible.

Note, however, that the exhaust gas temperature under all engine operating conditions at the sensor position must be less than 780°C otherwise the sensor may overheat. In general, installing the wideband sensor in the same position as the existing narrowband sensor should be OK.

You can check for sensor overheating by monitoring the heater impedance. This is done with jumper JP1 installed. The wideband output as measured between the tip and sleeve of a 3.5mm jack plug should normally be 684mV DC or about ±2% above and below this. If the Display Unit is connected (and is set up to measure lambda), it should show 0.85 (0.84-0.86 range).

If the sensor has overheated, the above-listed voltage or value will fall significantly. And if it's severely overheated, the Wideband Controller indicating LED will revert to its dim indication.

An overheating sensor will have to be relocated to a cooler section of the exhaust manifold, ie, further from the engine.

The following points should also be taken into consideration:

(1) The sensor must not be mounted in the exhaust manifold of a turbocharged engine. Instead, it must be installed after the turbocharger.

(2) The exhaust pipe section prior to the sensor should not contain any pockets, projections, protrusions, edges or flex-tubes etc, to avoid the accumulation of condensation water. Locating the sensor on a downward slope of the pipe is recommended.

(3) The sensor must be mounted perpendicular to the exhaust stream so that it can constantly monitor fresh exhaust gas. It must also be mounted so that it is inclined at least 10° from horizontal (electrical connection upwards) – see Fig.19. This is necessary to prevent condensation collecting between the sensor housing and the element.

(4) The recommended material to use for the threaded boss in the exhaust pipe is temperature-resistant stainless steel to the following standards: DIN 174401.4301 or 1.4303, SAE 30304 or 30305 (US). Fig.20 shows the threaded boss dimensions. Note that the sensor thread must be covered completely.

(5) The use of high-temperature resistant grease on the screw thread of the boss is recommended. The tighten-

Mounting The Oxygen Sensor On The Exhaust

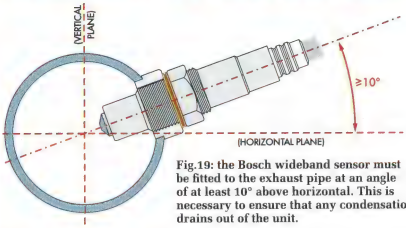


Fig.19: the Bosch wideband sensor must be fitted to the exhaust pipe at an angle of at least 10° above horizontal. This is necessary to ensure that any condensation drains out of the unit.

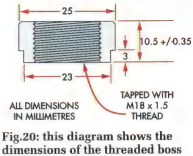


Fig.20: this diagram shows the dimensions of the threaded boss that's used to attach the sensor. It must be made of stainless steel and should cover the sensor's thread completely. The tightening torque is from 40-60 Nm.

ing torque is from 40-60 Nm.
(6) The sensor must be protected if an under-sealant such as wax or tar or spray oil is applied to the vehicle.
(7) The sensor must not be exposed to strong mechanical shocks (eg, during installation or removal using an impact driver). If it is, the element could crack and destroy the sensor without there being visible damage to the housing.
(8) Both the sensor and its connecting cable should be positioned to avoid damage due to stones or other debris thrown up by the wheels.
(9) Do not expose the sensor to water drips from the air-conditioner or from sources such as windscreen run-off during rain or when using the windscreen washer. The resulting thermal stress could damage of the sensor.
(10) Never switch on the sensor heating until the engine starts. This means that VR2 must be correctly adjusted to ensure heating does not begin until after the engine has started, as detected by a higher battery voltage (see setting-up procedure last month).

Using the S-curve output

As mentioned last month, the S-curve output from the Wideband Controller can be used to replace the existing narrowband signal. However, the vehicle must be currently using a zirconia-type narrowband oxygen sensor. If the vehicle already has a wideband sensor, then this sensor's output should not be replaced with the S-curve signal from the Wideband Controller.

A less common type of narrowband lambda sensor has a ceramic element made of titanium dioxide. This type does not generate a voltage but instead changes its resistance according to the oxygen concentration. Once again, this type cannot be simulated using the S-curve signal from the Wideband Controller.

Identifying the sensor leads

In order to replace the existing sensor with the S-curve output from the Wideband Controller, you first need to identify the leads running from the sensor to the ECU. Basically, there are four narrowband sensor variations:
(1) If the sensor has one lead this will be the signal wire and the sensor body will be ground.
(2) If the sensor has two leads, one will be the signal lead and the other will either be the signal common or (in the case of a heated sensor) a +12V heater lead. For a heated sensor, the body forms a common ground for both the signal and heater circuits.
(3) A 3-wire sensor usually has Heater+ (H+), Heater- (H-) and sensor signal leads, with the body as the signal ground. Alternatively, it could have a sensor signal lead, a sensor ground lead and a heater H+ lead, with the sensor body as heater H-.
(4) A 4-wire sensor is similar to a 3-wire sensor but with ground leads for both the signal ground and H-.

In each case, the leads are quite easy to identify but first a word of warning. **Do not measure the narrowband sensor impedance with a multimeter. The reason for this is that the current produced by the meter when measuring resistance may damage the sensor.**

Note also that the maximum loading for the sensor is 1µA. This means that to measure the voltage produced by a narrowband sensor, the meter must have an input impedance higher than 1MΩ. Digital multimeters (DMM) generally have an input impedance much higher than 1MΩ but an analog meter may not have the required high impedance.

The first step in identifying the leads is to set your DMM to DC volts, then connect the negative lead of the DMM to chassis. That done, it's a matter of starting the engine and probing the sensor's leads with the DMM's positive lead (a pin can be used to pierce the wire insulation but seal any holes with silicone afterwards to prevent corrosion.). The sensor's H+ lead will be at +12V, while its signal voltage lead will vary but should average over time at about 450mV.

Once these two leads have been identified, switch off the engine and unplug the sensor. The H- terminal can now be identified – it's the one that gives a low resistance reading of typically 5Ω (and usually less than 10Ω) to the previously identified H+ terminal **(warning: do not connect the meter probe to the previously identified signal terminal when making resistance measurements).**

The signal ground terminal is the one remaining.

In some cars, the ECU will check that the sensor is connected and

How To Remove The Original Narrowband Sensor

WHEN REPLACING an existing narrowband sensor with the LSU4.9 wideband sensor, make sure you remove the correct unit. The required sensor is the one that's between the exhaust manifold and the catalytic converter. A second oxygen sensor located downstream from the catalytic converter is there to monitor the latter's operation.

Removing the narrowband sensor may be difficult if you do not have the correct tools. The type of tool required depends on the sensor's placement. With limited height access, you may have to resort to using an open-ended 22mm (or 7/8-inch) spanner. In most cases, though, you should be able to use a special oxygen sensor removal tool. This uses a 22mm socket that has a slit along one side to allow the oxygen sensor wires to protrude (see photo below).

It's also common for the original oxygen sensor to seize in the threaded boss in the exhaust manifold pipe. As a result, the nut will refuse to budge and will simply start to "round off" under spanner tension. The main difficulty is that the socket or spanner needs to be an open-ended type, as a ring spanner or standard socket will not fit over the sensor connector. And an open-ended spanner tends to spread open under tension.

Even with the correct tool, removing a seized oxygen sensor can be difficult. In our case, we used "Loctite Freeze & Release Lubricant" (Part No. FAR IDH1024403) to help free it. This "shock cools", penetrates and lubricates the screw threads and this allowed us to eventually loosen and remove the sensor.

If you are not concerned about damaging the original sensor, its connector can be cut off so that a ring spanner can be slipped over it and onto the hexagonal nut. This can then be "tapped" with a hammer in the anticlockwise direction to loosen the sensor. Note, however, that this method will probably crack the ceramic material inside the sensor, leaving it permanently damaged.

Which ever method is used, Freeze and Release Lubricant is still recommended because it makes removal much easier. It also helps prevent the sensor nut from being rounded off, which would then make removal extremely difficult.

Note that special high-temperature grease should be used on the screw threads if you refit the existing sensor. That way, it will be easy to remove next time. A new sensor (such as the Bosch LSU4.9 sensor) will be supplied with this grease already applied to the thread.

This special oxygen sensor removal tool allows the sensor's leads to exit via a slot in the side of the socket. Make sure that the sensor leads turn with the sensor as it is undone.

produce an error code if it detects that anything is amiss. In most cases, however, the S-curve signal from the Wideband Controller will be accepted as valid but there are exceptions.

First, the ECU may check the sensor's impedance to determine if it is sufficiently heated (ie, when its impedance falls below a particular value). However, the impedance the ECU will measure at the Wideband Controller's S-curve output will be 150Ω and this may be incorrect for some sensors.

This means that the 150Ω output resistor may have to be changed in some cases, to prevent an error code from the ECU.

Heater fault indications

Some ECUs will also indicate a fault if the heater leads to the oxygen sensor are disconnected. In that case, you will have to keep the original heater connections to the old sensor and mount it in a convenient place away from parts that could melt (eg, against the firewall). Just make sure that the heated sensor cannot be accidentally touched, as it can run very hot.

Alternatively, you can make up a resistance box that has the same nominal resistance as the sensor's heater element when hot. The hot resistance will be higher than the cold resistance and can be measured by disconnecting the sensor lead immediately after the engine has reached operating temperature and then measuring the heater resistance using a DMM.

The alternative resistors should go in a diecast case and must be rated for to handle the power dissipation. In practice, the power rating is calculated by assuming a 14.8V maximum supply and a 50% derating. For example, if the heater hot resistance is 12Ω, then $14.8V^2 \div 12\Omega = 18.25W$.

In practice, a 40W resistor would be required and so the heater resistance could be simulated by connecting four 47Ω 10W resistors in parallel.

Because the Wideband Controller's S-curve output needs to simulate the original narrowband sensor, it's a good idea to check the operation of the original narrowband sensor when the car is running. This can be done using a multimeter and an oscilloscope to monitor the sensor's output. Alternatively, an OBD (On-Board Diagnostics) scan tool that shows live or real-time parameter data can be used to moni-

Mounting The O_2 Sensor In A Tailpipe Extension

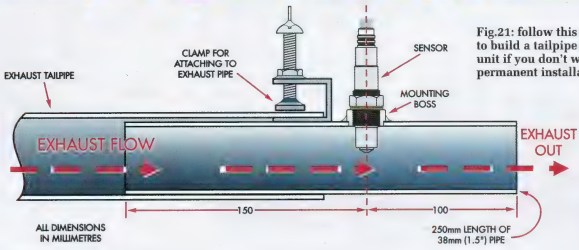


Fig.21: follow this diagram to build a tailpipe sensor unit if you don't want a permanent installation.

If you do not wish to install the wideband O_2 sensor permanently, an alternative is to mount it in a tailpipe extension. This tailpipe extension can then be slid over the end of the tailpipe and clamped in position – see Fig.21.

Note, however, that any readings obtained using this method will be affected by the catalytic converter and so won't be as accurate. That's because the catalytic converter reacts with the exhaust gas and changes the oxygen content. In addition, some catalytic converters include an air-bleed to feed oxygen into the exhaust to allow full catalytic operation with rich gases. This won't be a problem in older cars that don't have a catalytic converter.

Note that when the sensor is fitted to a tailpipe extension, TP2 in the Wideband Controller can be set for 4V. This will ensure that the sensor heater is immediately powered when the Wideband Controller is powered, without having to wait until the battery voltage rises when the engine is started (note: we don't have to wait in this situation because condensation is no longer a problem).

After use, make sure that the sensor is stored upright in a dry environment, to prevent moisture forming in the unit.

Fig.21 should be followed quite closely if you intend mounting the sensor in a tailpipe extension. By using the dimensions shown, the sampled exhaust gas is taken sufficiently upstream from the end of the tailpipe to prevent dilution with outside air.

The pipe and clamp materials can be made of steel or brass but use a stainless-steel boss for mounting the sensor.

tor the sensor voltage, if this feature is supported on your vehicle.

When the engine is warm and idling, the sensor reading should oscillate above and below 450mV at a rate dependent on the sensor's response rate and the ECU. By using the oscilloscope, the frequency of oscillation and the voltage can be directly measured (a multimeter will probably not respond quickly enough to show the full cyclic voltage range).

A typical narrowband sensor response is shown in Fig.22.

Connecting the controller

The Wideband Controller must be connected to the vehicle's 12V supply. The two ground wires are connected to chassis (adjacent to the lead from battery's negative terminal), while the positive lead connects to the ignition supply. **Make sure this supply remains at +12V while the engine is started as some switched ignition supplies (eg, for the sound system) are disconnected during engine starting.**

Next, replace the existing narrowband sensor with the wideband sensor, then connect the S-curve output from the Wideband Controller to the sensor+ signal input of the ECU. That done, check that TP2 in the Wideband Controller has been adjusted to 4.33V to ensure that the engine is must be started before the sensor is heated (see setting-up procedure last month).

To do this, first switch on the ignition without starting the engine and check that the LED on the controller is only dimly lit. This indicates that sensor heating has not yet started. Conversely, if the LED lights brightly, it indicates that the sensor is heating and so VR2 will need to be adjusted to give a higher voltage at TP2.

In practice, you may have to experiment to get the best setting for VR2 (as measured at TP2). If TP2 is too low in voltage, sensor heating will start before the engine starts. Conversely, if TP2 is too high, sensor heating will not start immediately after engine-starting and will not kick in until the battery voltage rises sufficiently. You can confirm this by revving the engine a little until the battery voltage rises high enough to start the sensor heating.

Note that you will need to switch off the Wideband Controller via the ignition and then back on again to have any changes to the TP2 voltage read by the controller. That's because this voltage is only checked at power-up, so always switch the controller off and on again each time you adjust VR2.

Using A Wideband Sensor In A Permanent Installation

AS A TEST, we installed a wideband sensor in place of the original narrowband sensor in a 2004 Holden Astra. The S-curve output from the Wideband Controller was then fed to the car's ECU (in place of the output from the original sensor).

This worked well, with no error codes produced by the ECU provided that the heater connections to the original narrowband sensor remained in place.

In operation, the narrowband signal from the Wideband Controller enabled the engine fuel mixture to cycle correctly above and below the stoichiometric value. In short, it proved to be compatible and the Holden Astra's engine ran normally.

This is in marked contrast to the Wideband Controller described in September and October 2009. With that controller, the overall response to the air/fuel mixture was too slow compared to that from the original narrowband sensor.

As a result, the engine RPM constantly varied at a fixed throttle setting as the air/fuel ratio varied above and below stoichiometric. This in turn varied the vehicle's road speed at constant throttle settings. As a result, the original Wideband Controller Mk.1 was unsuccessful as a permanent installation, at least in the Holden Astra.

By contrast, our new Wideband Controller Mk.2 using the LSU4.9 sensor produces a much lower range of RPM cycling at constant throttle above idle and with no load (transmission in Neutral). In fact, it's no more than occurs with the original narrowband sensor in place and is completely unnoticeable when the vehicle is being driven.

The correct setting for VR2 is critical to prevent sensor damage. Basically, it prevents the sensor from heating before the engine exhaust has blown out any condensation.

Note, however, that condensation only occurs after the sensor has cooled. If the Wideband Controller starts heating the sensor when it is already warm but before the engine has started, then that's OK. In practice, this means that VR2 should be set when the battery is at its normal resting voltage – ie, after the engine has been off for some time. For example, the battery voltage may be above 13V when the engine has just been switched off, but it will eventually drop to below 13V.

Once VR2 has been correctly adjusted, start the engine and monitor the S-curve output. It should cycle above and below 450mV in a similar manner to the original narrowband sensor.

If the S-curve simulation proves unsuccessful, either because the engine runs poorly or the ECU logs a fault code, then the narrowband sensor will have to be reinstalled. The Wideband Sensor will then have to be installed in a separate position. Often, fault codes can be cleared by disconnecting the vehicle's battery for a minute or so. Otherwise an engine-code reader will be required to clear the fault.

Note that disconnecting the battery may affect a security-coded sound system on some older cars, which means that and the security code will have to be re-entered. Disconnecting the battery or clearing a fault code using an engine-code reader could also reset some of the learned parameters stored in the car's ECU. These parameters include such things as engine timing (to prevent pinging) and fuel-mixture trim. These are tabled values made by the ECU during normal operation to improve engine running and fuel economy based on oxygen sensor readings and knock sensing. As a result, the engine may take a while to restore these parameters if they are cleared.

Pressure connections

If you wish to monitor the exhaust pressure, it will be necessary to drill a small hole through the exhaust pipe and then braze a short length of metal tubing (steel or brass) to the pipe near the sensor. This should be located on the downstream side, so that it doesn't provide a condensation point above the sensor.

The tube length should be such that the exhaust pipe heat is dissipated sufficiently for the rubber pressure tubing to attach without burning.

If you don't wish to monitor the pressure, just leave the port open (or leave the pressure sensor out and install the links as described in Pt.2).

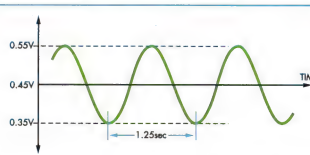


Fig.22: a typical narrowband sensor response when the engine is warm and idling. The output oscillates above and below 450mV as the ECU maintains a stoichiometric mixture.

Wideband controller tests

If you strike problems with your Wideband Controller, the best way to troubleshoot it is to first alter it to measure the oxygen content in air. That way, you can check the operating voltages in the circuit while the sensor monitors a known "mixture".

The necessary changes to the circuit are as follows:

Step 1: Disconnect the sensor and add a 560kΩ resistor in parallel with the 560kΩ resistor between pins 6 & 7 of IC3b. You can use TP7 and TP6 to terminate the leads of this resistor.

Step 2: Add a 560kΩ resistor in parallel with the 560kΩ resistor between pin 5 of IC3b and the Vs/Ip connection. You can use test points TP1 and TP5 to terminate the leads.

Step 3: Remove the 510Ω resistor in series with the 62kΩ resistor for the 20μA reference current and install another 62kΩ resistor in its place (ie, so that the total resistance between Vs and the +5V rail is 124kΩ).

Step 4: Apply power and adjust VR3

so that V_s/I_p is at 2V, as measured between TP1 and TP GND.

Step 5: Adjust VR4 so that TP4 is 2.343V.

Having made these changes, you can now troubleshoot the Wideband Controller as follows:

Step 6: Gently rest the sensor in a Pyrex bowl, connect it to the controller and apply power.

Step 7: Wait until the sensor has heated and the indicator LED flashes at a fast rate. Now check the various operating voltages on the circuit. The voltage between V_s/I_p (or TP1) and V_s should be 450mV. The voltage between TP11 and TP GND should be 2.5V.

However, there may be small variations from these values as the controller continually adjusts the current to maintain these voltages.

Step 8: If you have an oscilloscope, check that the 684mV p-p square-wave (used for sensor impedance measurement) is present at TP11. Alternatively, by inserting jumper JP1, the wideband output (as measured between the sleeve and tip connections of a stereo 3.5mm jack plug) will indicate the impedance of the sensor instead.

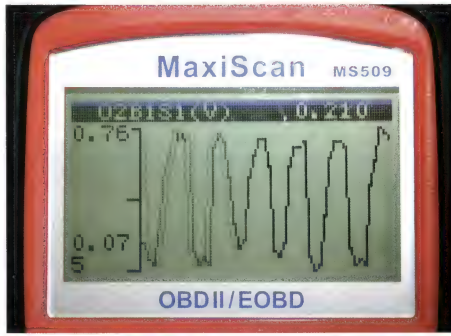
This should show 684mV DC for the sensor impedance to be kept at 300Ω. This may vary by ±2% or so as the controller maintains temperature, due to the resolution of the impedance measurement. Alternatively, if you have the Wideband Display unit connected (and set to show lambda), it should show a reading of 0.85 or 0.86.

Step 9: Check that TP12 (or TP7) is at 4V (ie, the V_s/I_p voltage of 2V plus the amplified voltage across the 62Ω resistor between R_{cal} & I_p). To explain, the I_p current through the 62Ω resistor should be 2.54mA when measuring 20.9% oxygen (ie, the oxygen content of air), so there should be 157.5mV across this resistor. IC3b operates with a gain of 12.73 (560kΩ//560kΩ ÷ 22kΩ), so this adds an extra 2V to the V_s/I_p voltage at TP12 to give a total of 4V.

Step 10: Check that the wideband output (between tip and sleeve) is at 2V with JP1 out. The Wideband Display should show 1.15 (if set to display lambda).

Note that if the air pressure is less than 1013hPa due to atmospheric conditions or altitude, the readings specified above may differ slightly. However, if VR3 has been correctly adjusted for altitude as detailed in Step 4 above, the error will be corrected.

This photo shows an original narrowband sensor at left and the Bosch LSU4.9 wideband sensor at right. The original sensor has exhaust gas entry slots in the side to provide faster exhaust gas access compared to the access at the base of the LSU4.9 sensor.



This OBDII diagnostic tool readout shows how the simulated narrowband (S-curve) output cycles about stoichiometric when the Bosch LSU4.9 wideband sensor and the Wideband Controller were installed on a 2004 Holden Astra. The horizontal scale is 10 seconds. The blurriness is due to display update movement as the trace moves leftward.

Resistor tolerances will also cause the voltage reading to differ. If necessary, the unit can be calibrated to give an exact 2V wideband output by changing the 62Ω resistor. To this end, the PCB has extra mounting holes so that a multi-turn 100Ω trimpot can be fitted instead. However, this modification shouldn't be necessary. Configuring the controller to measure the oxygen content in air is done to test the circuit's operation rather than check the sensor calibration.

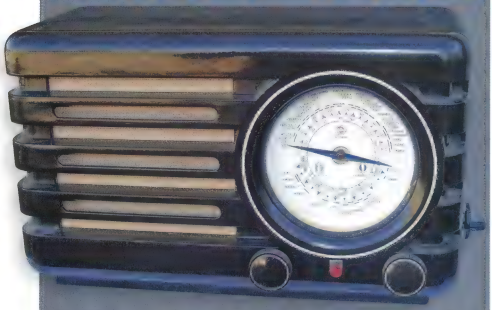
Step 11: Once all checks are complete, restore the circuit to normal operation by undoing the changes outlined in Steps 1-3 above – ie, remove JP1, remove the two extra 560kΩ resistors and replace the added 62kΩ resistor with the 510Ω resistor. That done, disconnect the sensor, apply power to the Wideband Controller and readjust VR3 to give 3.3V at V_S/I_p and VR4 to give 3.92V at TP4. SC

Vintage Radio

By Rodney Champness, VK3UG

The Philips BX373A 4-valve receiver

The set with the "Bibber Schaal" (shaky dial scale)



Until now, Vintage Radio has concentrated almost exclusively on Australian-made receivers. This month, however, we're going to take a look at a Dutch receiver, the Philips BX373A 4-valve table/mantel receiver from 1948. It's an excellent performer although the design is different to Australian sets.

THIS PARTICULAR Philips BX373 receiver is owned by John de Haas who has a fine collection of vintage radios, many of them originating from Holland (see SILICON CHIP, June 2012). And although it's a 4-valve set, the BX373A's performance rivals that of many 5-valve receivers. It operates on both the broadcast and shortwave bands, as well as the long-wave band.

As shown in the photos, the receiver is housed in a large, polished Bakelite cabinet with an interesting circular dial to the right. The On-Off/Volume control is towards the centre-bottom at the front of the cabinet, while the Tuning control is to the right. The Wave-Change switch is accessed at the righthand end of the cabinet, while the Tone control is at the opposite end.

The receiver is no lightweight and weighs a substantial 6kg. It's also quite large at 44 x 19 x 25cm (W x D x H), including the knobs. At that size, it could be considered to be either a table set or a mantel set.

The dial scale is unusual but attractive. It's also interesting in that it doesn't indicate the frequency being tuned but instead shows the approximate wavelength. I personally feel uncomfortable with this and prefer some indication of the tuned frequency.

As well as the wavelength indications, the dial-scale also carries corresponding country and city markings around the perimeter. The centre of the dial has three symbols which indicate how the Wave-Change knob should be set to select a particular band.

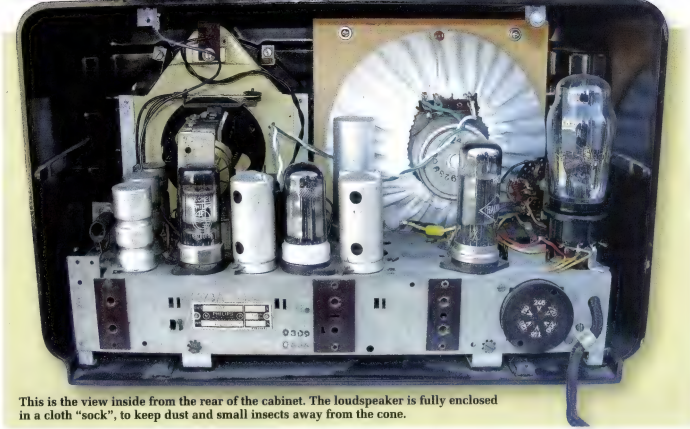
The back of the set is covered by a thin wooden panel with numerous ventilation holes. This panel carries a number of graphics which indicate the functions of the various sockets which are accessible through large clearance holes. These graphics not only helped people who were unfamiliar with radio terminology but also meant that the same panel could be used on sets exported to non-Dutch speaking countries.

Dismantling the receiver

Removing the chassis from the cabinet is straightforward. The first step is to remove the control knobs which are all push-on types. The four screws holding the rear panel in place are then removed, after which the screw holding the tone control's Bakelite shaft in place is loosened. Once that's done, this shaft can then be removed.

However, you have to be careful doing this as this Bakelite shaft is easily broken. And while it's possible to get a replacement from one enterprising enthusiast, it will set you back around $50!

Next, the four screws that go through the rubber buffers on the bottom of the cabinet must be removed, followed by the two screws that secure the front of the chassis to the inside front of the cabinet. These latter two screws are recessed several centimetres into the



This is the view inside from the rear of the cabinet. The loudspeaker is fully enclosed in a cloth "sock", to keep dust and small insects away from the cone.

cabinet, so you will need a special screwdriver for this job, especially when it comes to later reinstalling them.

In my case, I use a small screwdriver with spring-loaded clamps to hold the screw in place on the blade. Alternatively, if you don't have this type of screwdriver, a small amount of Blu-Tack or Kwik Grip on the screw head can be used to hold it in place while it is installed.

Once all the screws have been removed, the chassis can be slid out through the back. The only component left behind is the speaker, which is attached to the inside front of the cabinet.

First impressions

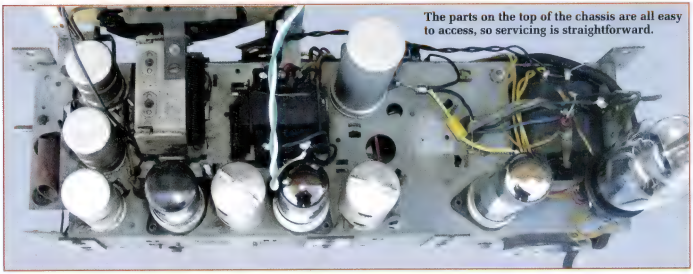
A quick examination of the chassis reveals a few initial surprises. It also has a few things that are different from Australian sets.

First, for some strange reason, the rectifier socket is mounted proud of the chassis instead of flush-mounted. It almost looks as though the designers forgot that they needed space for a rectifier when the chassis layout was being decided on.

In addition, as with many other European sets, the power transformer and the associated wiring to it are not as well-protected against accidental contact compared to Australian designed sets. On the other hand, once in the cabinet and with the rear panel fitted, this European receiver is just as safe as an Australian set.

One unusual feature is that the speaker is fully enclosed in a cloth "sock", to keep dust and small insects away from the cone. This helps ensure that the speaker cone stays in good condition and contributes to the long life of the speaker.

Another unusual feature is the tun-



The parts on the top of the chassis are all easy to access, so servicing is straightforward.

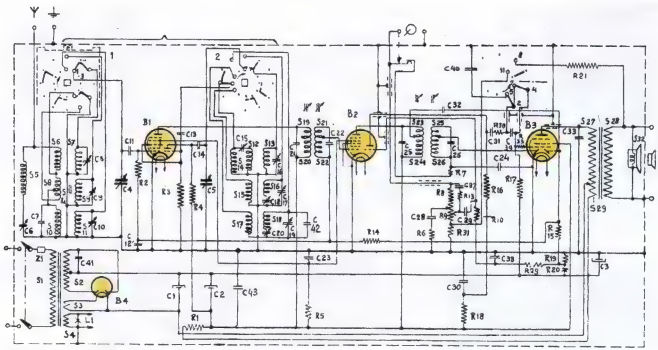


Fig.1: the circuit is a fairly conventional 4-valve superhet design. Note that the detected audio from valve B3 is fed back to the grid of the triode section in valve B2. This signal is then amplified by B2 and fed to the grid of B3 which further amplifies the signal and drives the loudspeaker via an output transformer.

Did the designers forget to leave space for the rectifier when they designed the chassis? For some strange reason, it's mounted proud of the chassis instead of sitting down flush.

ing capacitor mounting arrangement. If you touch the tuning capacitor, you immediately discover that it is on a very flexible mounting. As a result, it wobbles around quite a bit more than usual, hence the set's Dutch nickname of "Bibber Schaal", which roughly translates to "Shaky Scale".

It make me wonder just how stable the tuning is on shortwave if the set is given a bump!

Under the chassis, the multi-band tuning and switching arrangement is very compact and servicing this part of the circuit would be awkward. It would also make alignment adjustments a little more difficult than usual.

Circuit details

Take a look now at Fig.1 for the circuit details. It's a fairly conventional superhet design with four valves, including the rectifier.

The first thing to note is that although there is provision for an external antenna, a "plate" antenna is also provided for those who consider an antenna a nuisance. This plate antenna consists of foil plate glued to the inside of the back panel and this is attached to the antenna input in parallel with a lead from the external antenna terminal. In strong signal areas, a plate-type antenna will work quite well but an outside antenna will provide the best performance.

The front-end is typical of that used in many European sets. It's a triple-band design with long-wave (150-420kHz), medium-wave (517-1620kHz) and shortwave (5.9-18.75MHz) tuning capabilities. In Australia, the long-wave band was used for only a very short time when public radio broadcasts first started in the 1920s. These days, the band is used for navigational beacons which send out tone-modulated Morse code identification or computer spoken weather reports for aircraft.

The 3-band antenna and oscillator tuned circuits are selected as required by the band-switch. As shown, the antenna terminal is connected to a series-tuned circuit consisting of coil S5 and C6. These are tuned to the 452kHz IF (intermediate frequency) and this minimises signal breakthrough from stations at the high-frequency end of the long-wave band. This is necessary because these stations operate at frequencies close to the IF (down to a minimum of just 32kHz away).

The tuned input signal is applied to the signal grid (grid one) of the heptode section of valve B1, an ECH21 triode-heptode converter. The oscillator signal is applied to grid three, so that the incoming signal is converted to the 452kHz IF.

The selected output signal on 452kHz is taken from the anode and applied to the heptode section of valve B2, another ECH21, via a double-tuned IF transformer (in this case, the triode section is not connected to the heptode). The amplified signal is then fed via a second double-tuned IF transformer to valve B3, an EBL21 duo-diode power output pentode.

As an aside, AWV in Australia later developed the 6BV7, a 9-pin miniature valve with similar characteristics to the EBL21. It wasn't as reliable as the EBL21, however.

Getting back to Fig.1, the detector diode in B3 is fed from a tap on the secondary of the IF transformer. The detected audio signal is then fed back to the grid of the triode section of valve B2 where it is amplified and applied to the grid of B3. B3 in turn drives the speaker transformer and the set's internal speaker.

There is also provision for an extension speaker and this can be plugged in via a socket on the back panel. Note that negative feedback from the speaker's voice coil is routed back via R21 and the tone control switch (shown just above valve B3 on the circuit).

Pick-up inputs

The rear panel also provides access to a pair of pick-up inputs, so that records can be played back via the audio amplifier stages of the receiver. To prevent interference from the front-end stages, the output from the detector is open-circuited when the pick-up lead is plugged into the rear-panel socket (see top of circuit). The RF and IF stages of the receiver remain fully operational, however.

In practice, this means that if the set just happens to be tuned to a very strong station, some leakage of the detected audio signal would almost certainly occur across the pick-up socket. That, in turn, would result in a weak radio signal audibly interfering with the signal from the record player.

Rendering the front-end of the receiver inoperative by removing the HT to some or all of that section would have completely eliminated this problem. However, simply tuning off the station may also have been enough to prevent interference.

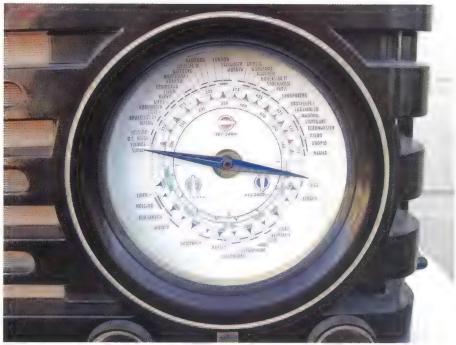
The ventilated panel at the rear of the set carries graphics which indicate the functions of the various sockets. As well as antenna and earth terminals, the set has pick-up input terminals and an external loudspeaker output socket.

Power supply

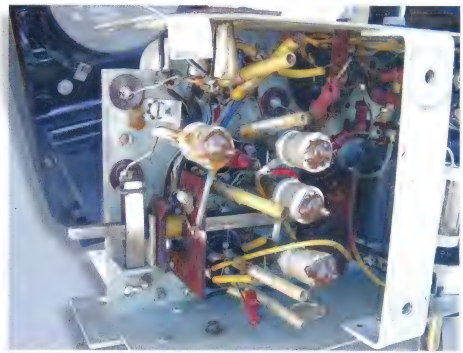
The power supply is conventional and includes a power transformer with six primary tappings to cater for mains voltages ranging from 110VAC to 245VAC. The secondary has three windings: a 4V winding for the rectifier heater, a 6.3V winding for the other valve heaters and a centre-tapped HT (high-tension) winding. The two outer leads of this HT winding go to the anodes of rectifier valve B4.

B4 is an AZ1, which is a duo-diode rectifier. Its HT output is fed though a winding on the audio output transformer and this not only provides ripple filtering but also bucks any hum which may be present on the grids of the audio amplifier stages.

Despite the set's age, the chassis was in excellent condition and very little work was required to restore it to full working order.



The dial-scale on the Philips BX373A is rather unusual, with wavelength rather than frequency indications. In addition, the perimeter carries various European country and city markings.



This close-up view shows the band-switching assembly. The compact layout makes it awkward to service and align correctly.

The set's power consumption is around 45W, which is about average for this type of set.

Delayed AGC

As shown on Fig.1, a back-bias network is connected across the centre-tap of the secondary winding on the power transformer. This network provides bias for valve B3 (EBL21) and for the triode section in B2 (ECH21), as well as providing a delayed automatic gain control (AGC) voltage source for both B1 and B2.

Valve B3 has two detector diodes inside its envelope. One is used as the detector, while the other is used to provide delayed AGC. In this case, a standing bias of about -2V is obtained from the junction of R19 and R20. This is fed via R15 to B1 and B2 to ensure correct operation before AGC voltage is applied.

This bias voltage is also fed to the AGC diode in B3, while a sample of the detected audio signal is derived from the primary of the second IF transformer and also fed to the AGC diode. As a result, a strong signal will quickly equal or exceed the negative bias (applied via R15) on the AGC diode, to control the gain of the front-end stages.

Summary

Despite being only a 4-valve set, the Philips BX373A is effectively equivalent to a 5-valve set and performs accordingly. The valves used are ones not commonly used in Australia and they also have base layouts which were not much used here either. In fact, the valves can be considered to be high-performance units and this set was designed to a high standard for the time (around 1948).

One area of criticism is that this set has controls which emerge through the sides of the cabinet – in this case, the wave-change switch at one end and the tone control at the other. The tone control in particular is very poorly thought out and it shouldn't have been all that difficult for it to have been fitted to the front skirt of the chassis.

Of course, the BX373A is not alone in placing some controls like this and some designs even have controls at the back of the set as well.

John has the original service manual for the set and although it's printed in Dutch, it's still quite easy to understand most of the information in it. This includes the dial-stringing arrangement, which is rather unique (to put it mildly) due to the very flexible dial drive and tuning capacitor mounting. It certainly deserves the "Shaky Scale" nickname.

Other useful diagrams show the wiring layout for both the top and underside of the chassis.

In summary, the Philips BX373A is a well-designed set that performs extremely well and looks very appealing. It didn't require a large number of parts for John to restore it good working condition, which indicates that Philips used good quality parts during manufacture.

This is one of John's favourite receivers and it makes a fine addition to a collection. SC

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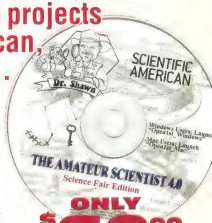

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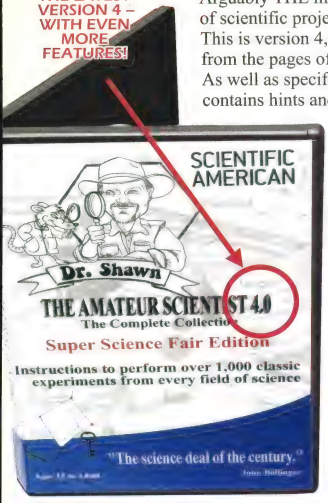

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12AX7 VALVE AUDIO PREAMPLIFIER	NOV 2003	01111031	$25.00
POOR MAN'S METAL LOCATOR	MAY 2004	04105041	$10.00
BALANCED MICROPHONE PREAMP	AUG 2004	01108041	$25.00
LITTLE JIM AM TRANSMITTER	JAN 2006	06101062	$25.00
POCKET TENS UNIT	JAN 2006	11101061	$25.00
STUDIO SERIES RC MODULE	APRIL 2006	01104061	$25.00
ULTRASONIC EAVESDROPPER	AUG 2006	01208061	$25.00
RIAA PREAMPLIFIER	AUG 2006	01108061	$25.00
GPS FREQUENCY REFERENCE (A) (IMPROVED)	MAR 2007	04103073	$55.00
GPS FREQUENCY REFERENCE DISPLAY (B)	MAR 2007	04103072	$30.00
KNOCK DETECTOR	JUNE 2007	05106071	$25.00
SPEAKER PROTECTION AND MUTING MODULE	JULY 2007	01207071	$25.00
CDI MODULE SMALL PETROL MOTORS	MAY 2008	05105081	$15.00
LED/LAMP FLASHER	SEP 2008	11009081	$10.00
12V SPEED CONTROLLER/DIMMER *(Use Hot Wire Cutter PCB from Dec2010 18112101)*	NOV 2010	18112101	$25.00
CAR SCROLLING DISPLAY	DEC 2008	05101092	$25.00
USB-SENSING MAINS POWER SWITCH	JAN 2009	10101091	$45.00
DIGITAL AUDIO MILLIVOLTMETER	MAR 2009	04103091	$35.00
INTELLIGENT REMOTE-CONTROLLED DIMMER	APR 2009	10104091	$10.00
INPUT ATTENUATOR FOR DIG. AUDIO M'VOLTMETER	MAY 2009	04205091	$10.00
6-DIGIT GPS CLOCK	MAY 2009	04105091	$35.00
6-DIGIT GPS CLOCK DRIVER	JUNE 2009	07106091	$25.00
UHF ROLLING CODE TX	AUG 2009	15008091	$10.00
UHF ROLLING CODE RECEIVER	AUG 2009	15008092	$45.00
6-DIGIT GPS CLOCK AUTODIM ADD-ON	SEPT 2009	04208091	$10.00
STEREO DAC BALANCED OUTPUT BOARD	JAN 2010	01101101	$25.00
DIGITAL INSULATION METER	JUN 2010	04106101	$25.00
ELECTROLYTIC CAPACITOR REFORMER	AUG 2010	04108101	$55.00
ULTRASONIC ANTI-FOULING FOR BOATS	SEP 2010	04109101	$25.00
HEARING LOOP RECEIVER	SEP 2010	01209101	$25.00
S/PDIF/COAX TO TOSLINK CONVERTER	OCT 2010	01210101	$10.00
TOSLINK TO S/PDIF/COAX CONVERTER	OCT 2010	01210102	$10.00
DIGITAL LIGHTING CONTROLLER SLAVE UNIT	OCT 2010	16110102	$45.00
HEARING LOOP TESTER/LEVEL METER	NOV 2010	01111101	$25.00
UNIVERSAL USB DATA LOGGER	DEC 2010	04112101	$25.00
HOT WIRE CUTTER CONTROLLER	DEC 2010	18112101	$25.00
433MHZ SNIFFER	JAN 2011	06101111	$10.00
CRANIAL ELECTRICAL STIMULATION	JAN 2011	99101111	$30.00
HEARING LOOP SIGNAL CONDITIONER	JAN 2011	01101111	$30.00
LED DAZZLER	FEB 2011	16102111	$25.00
12/24V 3-STAGE MPPT SOLAR CHARGER	FEB 2011	14102111	$15.00
SIMPLE CHEAP 433MHZ LOCATOR	FEB 2011	06102111	$5.00
THE MAXIMITE	MAR 2011	06103111	$25.00
UNIVERSAL VOLTAGE REGULATOR	MAR 2011	18103111	$15.00
12V 20-120W SOLAR PANEL SIMULATOR	MAR 2011	04103111	$25.00
MICROPHONE NECK LOOP COUPLER	MAR 2011	01209101	$25.00
PORTABLE STEREO HEADPHONE AMP	APRIL 2011	01104111	$25.00
CHEAP 100V SPEAKER/LINE CHECKER	APRIL 2011	04104111	$25.00
PROJECTOR SPEED CONTROLLER	APRIL 2011	13104111	$10.00
SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	CODE:	Price:
100W DC-DC CONVERTER	MAY 2011	11105111	$25.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00
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USB STEREO RECORD/PLAYBACK	JUNE 2011	07106111	$25.00
VERSATIMER/SWITCH	JUNE 2011	19106111	$25.00
USB BREAKOUT BOX	JUNE 2011	04106111	$10.00
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DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$15.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$25.00
ULTRA-LD MK2 AMPLIFIER UPGRADE	SEP 2011	01209111	$5.00
ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	$45.00
GPS FREQUENCY REFERENCE (IMPROVED)	SEP 2011	04103073	$55.00
DIGITAL LIGHTING CONTROLLER LED SLAVE	OCT 2011	16110111	$30.00
USB MIDIMATE	OCT 2011	23110111	$30.00
QUIZZICAL QUIZ GAME	OCT 2011	08110111	$30.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$35.00
ULTRA-LD MK3 INPUT SWITCHING MODUL	NOV 2011	01111112	$25.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$30.00
DIGITAL AUDIO DELAY FRONT & REAR PANELS	DEC 2011	01212112P2/3	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04105121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04105122	$20.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER	APR 2012	10105121	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER F&R PANELS	MAY 2012	21105122/3	$20 per set
MIX-IT-4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
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CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
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Some micros from copyrighted and/or contributed projects may not be available.

As a service to readers, *SILICON CHIP* is now stocking microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – **pre-programmed and ready to fly!** **Price for any of these micros is just $15.00 each + $10 p&p per order#**

PIC12F675	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10); Cricket/Frog (Jun12)
PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11), Quizzical (Oct11), Ultra-LD Preamp (Nov11)
dsPIC33FJ64MC802-E/SP	Induction Motor Speed Controller (Apr-May12)
ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
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When ordering, be sure to nominate BOTH the micro required and the project for which it must be programmed.

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08/12

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Write to: Ask Silicon Chip, PO Box 139, Collaroy Beach, NSW 2097 or send an email to silicon@siliconchip.com.au

How to select resettable fuses

I have a question related to resettable fuses. These devices have a "holding current" which is a safe current through the device and also a "trip current", the point at which the device interrupts the current flow.

For example, the MF-R300 has a holding current of 3A and a trip current of 6A. What I'm confused about is what happens when the current is, say, 4.5A? I am guessing the fuse wouldn't trip at 4.5A but would it eventually trip if that current is maintained?

Furthermore, the data sheet at **http://www.farnell.com/datasheets/90504.pdf**, under the "typical time to trip" section, states that the MF-R300 will trip after a second at 20A. This seems very high seeing that earlier in the data sheet it says the trip current is 6A.

Can you inform me on the correct way to select a resettable fuse? Let's say my device under normal conditions can draw anywhere from 0-3A. Any more than about 3A is not normal and a fault may be present.

How would I go about determining what resettable fuse I'd need? (B. W., via email).

● Fuse rating for holding and trip current are based on time. The MF-R300 fuse is designed to stay closed at the holding current for at least 30 minutes (1800s). It will trip before five times that period (ie, 2.5 hours). In other words, the MF-R300 will trip at 3A between 30 minutes and 2.5 hours.

According to the graph in the data, the fuse will trip at 6A after about 1000s. At higher currents it will trip more quickly. The data table shows that it will trip at 15A within 10.8 seconds.

So the holding current is the current that the fuse will trip (eventually) but at higher currents it will trip faster. So if your device does not draw a continuous 3A, then the MF-R300 will be suitable. If it does draw 3A on a continuous basis, then the MF-R400 (4A) might be better to prevent nuisance tripping.

Setting the delay on a VOX circuit

I have been looking for a VOX relay that could switch on a very small amplifier when it receives an audio signal (for example, from an Apple Airport Express) and would subsequently turn off a couple of minutes after the signal disappears, ie, so it doesn't turn off between tracks.

Through the wonders of Google, I stumbled on the VOX circuit published in July 2011. Will this project be suitable? Where can I buy a kit or the components? (M. P., via email).

● The VOX from July 2011 should be suitable for your application. Time-out is a maximum of 10 seconds but this could be increased to a longer period using a 470µF capacitor at the cathode of diode D4 instead of the 100µF value.

There is no kit available but the PCB, code 01207111, can be obtained from SILICON CHIP for $25. Contact **pcbs@siliconchip.com.au**

The components are available from Jaycar and Altronics: **www.jaycar.com.au** and **www.altronics.com.au**

Using the VOX for PA work

The VOX article in the July 2011 issue of SILICON CHIP is stated to be suitable for PA systems or amateur radio use. However, I believe that the circuit has an omission which precludes its use for these purposes. It does not have any means of extracting the audio from the microphone to then use it for the PA or amateur transceiver.

A small addition to this circuit would enable this to be done. Any ideas for a modified VOX to be able to control the relay and allow the audio

Browns Gas Is A Fraud

I have been reading SILICON CHIP since its inception. It keeps the mind up with the tech times. My friend is running his car on a mixture of HHO. I have been following this subject for years. As someone said, "I wish those calling this a joke would stop pestering those doing it".

I have just been and seen a small Briggs and Stratton engine running on pure HHO (water). Being an experiment, the metering was wrong and after a few minutes it blew the head gasket. I would love to see more on this subject especially for generators that run constant speeds.

So far people are tinkering with dozens of configurations. We need topics from SILICON CHIP on EFIEs, pulse circuits to play with and get Australia ahead of the world that is now marketing this subject in welders and fuel alternatives.

Considering that Browns Gas is an Australia patent, let's get behind him. (M. R., via email).

● Brown's gas is not an Australian patent. It is a load of rubbish. Why is there still any interest in this topic? There was a Publisher's Letter on this topic in the November 2008 issue and a detailed answer on the topic in the "Ask SILICON CHIP" section on pages 89 & 90 of the September 2008 issue.

We hesitate to even mention the topic again because a whole new cohort of gullible people with no knowledge of science will want to jump on the band-wagon again. Doesn't the fact that the small engine in your demonstration blew up cast any doubt on the whole concept?

If you really want the background on this topic, ignore everything you might have read on the internet and refer to the articles above. That should end all interest but sadly, we know it won't.

to be used as well? (C. M., via email).

● Typically, a signal is taken or tapped off from the transceiver or public address (PA) system to obtain a signal to trigger the VOX. Since we are not breaking the signal to the transceiver or PA but just tapping it off, the transceiver or PA unit will still have an audio signal. There is no need to tap the signal from the VOX itself for the PA or transceiver.

An electret microphone is usually connected when the VOX is used for a stand-alone sound activated switch rather than when used with a transceiver or PA.

However, tapping the signal from the VOX is possible using either the 3.5mm jack socket or the screw terminals. These essentially provide a signal in and loop out (as a parallel connection). If you require an amplified signal, the pin 1 output of op amp IC1a can be used provided it is fed via a capacitor to block the DC level.

Mains isolation switch required

Due to weather and other influences, we lose the power grid from time to time. I then drag out my 2.3kW generator to supply my fridge, lights and TV. So there are power leads all over the place; most untidy.

I would like to have my distribution board modified so that I could cut off the grid altogether and then plug in and run my generator until the power comes back up. How should I go about doing this? (S. S., via email).

● The best way to arrange this is to have an electrician install an isolating switch or solenoid. That way, all your household or selected circuits can be powered from your generator when needed. You can even leave the generator permanently connected, ready to be switched over at any time.

Trying the SoftStarter with an inverter (1)

With reference to the SoftStarter project in the April 2012 issue, can this device be used to run an 385W water pump motor from a 12V to 230V inverter (pure sinewave)?

When used directly, the high start winding current trips the inverter cut-out. I understand that the starting current is up to 10 times the run current. By using the SoftStarter will this decrease the high initial burst of current and also allow the motor to start and run normally?

I am attempting to run my water pump from solar-powered batteries. (L. S., via email).

● Presumably, you want the pump motor to start repeatedly, ie, each time you turn on a tap. This means that the April 2012 design is not suitable. You need the later design featured in the July 2012 issue – see the answer below.

Trying the SoftStarter with an inverter (2)

Could you please tell me if either of the SoftStarter projects, ie, from the April or July 2012 editions, would be suitable to reduce the start-up current of a chest freezer, potentially enabling the freezer to be run in a remote location using a lower-power inverter, eg, 300W to 600W? (P. B., via email).

● A typical chest freezer needs about 200W continuous power when the compressor is running so a 300-600W inverter should be OK once it has started. The SoftStarter *may* solve the issue of the compressor start-up current causing the inverter to trip off but we're not sure because there are three potential problems:

(1) It may limit the in-rush current so much that the compressor fails to start until the relay clicks in, at which point the inverter would be subjected to the full in-rush current and likely trip off.

(2) It may not limit the in-rush current enough and the inverter may trip off anyway.

(3) The Soft Start delay may be too short and the inverter could trip off once the relay clicks in.

You can potentially solve problem (3) by increasing the delay, which can be done by substituting a larger time delay capacitor.

All we can suggest is to try it and see if it works. The Soft Starter for Power Tools from July 2012 would be the one to use since you need it to autoreset once the freezer temperature has dropped far enough for the compressor to turn off. Otherwise, the inverter will trip next time it turns on again.

Powering PIC Microcontrollers

I am currently designing a circuit that drives two printer stepper motors and a few PIC microcontrollers for a CNC machine. I have a 15V power supply. I am planing to use a simple resistive divider to divide the voltage to 5V for the PIC chips and drive the steppers through an L293D H-bridge and with the chips in parallel. Is this correct or are there better ways to set up the circuit? (V. K., via email).

● You can use a voltage divider to get the 5V rail for the microcontrollers but it's generally not a good idea for a few reasons. First, the resulting voltage will track the 15V supply and that may vary substantially depending on the supply itself, what the motors are doing, etc.

Also, because the microcontrollers are in parallel with the bottom leg of the divider and they have a variable impedance, the resulting voltage will be lower than you would expect and will vary depending on what they are doing (sleeping, idling, running etc).

That means you would need to use quite low value resistors, to ensure sufficient current to swamp these effects and that wastes power.

The next best solution is to replace the bottom resistor in the divider with a zener diode or a shunt regulator. That virtually eliminates variations in supply voltage with load impedance but that configuration still wastes quite a bit of power (usually at least 10mA to ensure correct zener operation).

We suggest using a linear regulator like the 78L05 instead. They are quite cheap (under a dollar from most suppliers), only draw 3mA and provide near-perfect regulation but should have a capacitor connected across the input and output (10µF is sufficient). With a 15V supply, you can draw about 50mA from the 5V output. For more current, you can put a resistor in series with the input, sized to drop about 7V at maximum load. Above 100mA, use a 7805T.

You certainly can connect multiple microcontrollers or L293D H-bridge ICs in parallel. It's always a good idea to connect a 100nF capacitor between the supply pins of each device, as close as possible, to overcome supply track/wire resistance and inductance.

12V AC Pump Driver Circuit Wanted

I have been a subscriber for many years and I have searched through my piles of journals for a circuit to drive a low-voltage AC pond pump from a solar panel, without success.

I have in mind the 12V AC synchronous motors which are magnetically coupled to a small impeller and totally submersed. They usually draw around 10-20W and are very reliable over time with continuous use compared with a small DC pump. It need not run continually and if the panel has sufficient capacity, the battery could still be charging when the pump runs.

For example, 50W panels are now very cheap and should have enough overhead to charge a 12V SLA battery which then drives a small inverter circuit. The circuit could incorporate a timer and battery cut-out.

Incidentally, I have been running a large 3-phase lathe and a 3-phase medium size turret mill in my workshop with a single 2.5kW Variable Frequency Drive, 240V single phase in, 240V 3-phase out. I was lucky in that both motors were 6-wire so they could be rewired, however the switch gear, power feeds and coolant pumps have to be wired separately to the variable frequency supply.

Commonly, these motors run off 110VAC via an auto-transformer picking off one of the phases. Any relays are 24V, again off the transformer, so care has to be taken with this aspect of any conversion; a point not mentioned in any of the recent articles on the Induction Motor Speed Control. You cannot expect to plug your 3-phase machine into the converter and have it run properly without some extra wiring. Great magazine! (S. S., via email).

● We published the exact circuit to drive a 12V AC pump as a Circuit Notebook item in the March 2009 issue, entitled "Solar-powered Fountain Driver". It was based on a PIC12F675 and had four Mosfets to drive the pump in bridge mode.

13.8V soft-start circuit wanted

I am looking for a circuit to soft-start 13.8V circuits. Years ago, I had such a circuit (from *Electronics Australia* – RIP) that I used to control driving lights on a rally car. I would like to do the same again but can no longer find it. I wonder if you have or will be describing a 13V Soft Start system? (S. C., Aloha, Oregon, USA).

● The 12/24V 20A Motor Speed Controller from the June 2011 issue can be used to soft-start. When power is applied (and if the soft start selection jumper LK1 is inserted), the PWM will increase over time up to the setting provided by the speed pot. The speed pot can be set to maximum if the full voltage is required after soft start.

Using the Frequency Switch as a rev limiter

I have purchased your Frequency Switch project and would like to use it as a rev limiter on my car which would cut the ignition, as the standard one cuts the fuel supply and is not good for my engine at high RPM. I was wondering how you would configure the unit and wire this into my vehicle. There has been talk on forums about needing an immobiliser unit from SILICON CHIP that is to be used with the switch. (B. F., via email).

● The Frequency Switch can be set up to switch the relay at a preset RPM. It should be connected to monitor the tachometer signal. The relay can be used to shunt the coil drive.

In other words, the common (C) and normally open (NO) relay contacts are connected across the ignition coil transistor (usually to the coil negative and chassis). This will work if you have a single coil and distributor but you need to be sure the coil can withstand this extra connection time across the 12V supply while rev limiting of the engine is taking place.

For cars with separate coils for each cylinder, this approach does not work. And you cannot disconnect power to the coils as this will produce a rogue spark that could damage the engine.

In this case, the only approach is to throttle back the fuel injectors. This is best done in small steps rather than abruptly stopping the fuel. A "Shift Indicator and Rev Limiter" using that approach was published in the February 2008 issue.

We are not sure why you say that the standard rev limiter already installed in your vehicle that simply cuts the fuel is not good for the engine. Cutting fuel will prevent backfire (compared to ignition cut out) and the limiting action should limit the engine RPM fast enough so that the engine is not starved of fuel for cylinder cooling for a long period. The lack of firing without fuel will prevent heat rise anyway.

How to program dsPIC33 micros

Can the PIC Programmer (SILICON CHIP, May 2008) program the dsPIC33 series, particularly the 28-pin device used in the SD Sound Recorder (August 2009)? I want to make some software changes. The programmer does not seem to have a compiler to produce hex files. Is one available? (A. A., Canberra, ACT).

● The May 2008 PIC Programmer can not program the dsPIC33 series without modifications because they require a different supply voltage (3.3V rather than 5V) as well as a capacitor from the "Vcore" pin to ground.

You could possibly modify that programmer to work with dsPIC33s but you may be better off buying a PICkit3 (less than $50, available at Element14, for example) and then just wiring a 5-pin header to the SD sound recorder PCB with some flying leads. A small piece of Veroboard can be used to do this.

A better approach may be to build the PIC/AVR Programming Adaptor Board (May & June 2012). This can program dsPIC33s and many other PICs. It works in conjunction with the aforementioned PICkit3.

Compilers for PICs are available from Microchip (**www.microchip.com**) with a free trial period.

Upgrading the switch in an electric kettle

Would you be interested in a project for improving reliability of an electric kettle? It is essentially a simplified Triac light dimmer circuit which is controlled by the kettle switch. The kettle switch should last much longer because it is no longer switching

230VAC and 8A. (V. V., via email).

● This is an interesting idea to extend the switch life but there isn't any easy way to remove the Triac heat (about 8W) in such a confined space. The main power switch usually is switched off by an in-built thermostat when the water boils.

Probably most kettle switch failures would be due to steam and moisture causing corrosion in the switch mechanism and contacts. This could well be more of a problem if the main switch is used as a low-current switch for a Triac, whereby there will be no contact cleaning by the normally heavy load current.

Converting beer slabs to frozen slabs

A customer of mine built the Tempmaster thermostat in order to control the temperature of a beer freezer. However, he returned shortly afterwards saying that it only has a range of 2°C to 19°C. It turned out he wanted to achieve a range of around -10°C to -18°C with it.

After looking at the circuit, I figured out how to increase the range (change the 500Ω pot to 1kΩ) but I'm stumped as to how I would decrease the lower limit of the thermostat. Any help would be much appreciated. (T. M., Newcastle, NSW).

● It sounds like your customer wants to make beer ice blocks! Anyway, there's no problem in modifying the Tempmaster Mk.2 to cover the temperature range he wants. You don't even have to change the value of trimpot VR1; it can stay at 500Ω. All you need to do is replace the 3.3kΩ resistor in series with the trimpot with a resistor of 2.7kΩ. This will shift the sensing range from -23°C (with VR1 at minimum resistance) to -2°C (with VR1 at maximum resistance). As you can see, this is wider than the range he wants.

However, simply setting the Tempmaster to a temperature setting within the range of -10°C to -18°C won't necessarily make his "beer freezer" lower the temperature that far. If the freezer's compressor/chiller unit is not capable of cooling the beer down to that temperature, all that will happen is that the Tempmaster will keep the compressor running continuously.

Troubleshooting The G-Force Meter

I built the G-Force Meter (SILICON CHIP, November 2011) and when I turned it on for the first time, the LEDS flashed and then there was nothing. I get 3V at the source and at the chip too and I get 3V across all the pins of the PIC. Any ideas? (S. S., via email).

● If you are getting 3V at all pins of the PIC, that suggests you have a break somewhere in the negative lead of the battery or on one of the ground tracks of the PCB. It's also possible that the chip isn't making good contact with the socket at the ground pin.

The upper-right pin of the PIC18-LF13K22 (pin 20) is connected to ground. This track runs via the ICSP header (pin 3), along the top of the PCB to the left, through Q1's pad, then down around the edge of the PCB and to the battery negative pad. Check that you have continuity between the battery negative terminal and pin 20 of the PIC.

If you are getting 0V at pin 20 of IC1 (the expected voltage) and all the other pins are at 3V, there may be a fault with the PIC chip itself. If you programmed the chip yourself, use your programmer to check that it's still functional and to verify it has the correct program loaded.

Bigger shed light project wanted

I'm considering building the Solar-Powered Shed Light project from the May & June 2010 issues but I have two important questions to ask.

The first concerns whether the control circuit includes a low-battery switching function to cut off the lights should the state of the battery drop

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Powering a WW2 Gyro-Compass

Some time ago I purchased a second-hand WW2 gyro-compass. With the help of some war museum staff, I have obtained enough information to indicate that it operates on 3-phase, 115V phase-to-phase, delta-connected (my estimate is less than 100mA) at 400Hz. Can the Induction Motor Speed Controller featured in the April & May 2012 issues be modified to provide these requirements? Maybe a much simpler circuit would apply as the frequency and voltage can be fixed.

There is also a technical complication in that one phase must be earthed. If the circuit cannot allow for this, then I would feed it through an isolating transformer of which a suggested design would be appreciated.

I suggest that such a circuit would be of interest to many museum staff who at present are operating such instruments on old rotary converters (if they are available). Rotary converters were the source of power for many of the instruments in aircraft. (D. C., via email).

- It would not be a simple matter to reconfigure the Speed Controller for 400Hz 115V operation. As well as new software, there would need to be a 3-phase output transformer, since we don't think 115V devices would tolerate the 300V peak output waveform, even if they could cope with the switching waveforms. We have no expertise on aviation power, so don't know if one phase is earthed or if there is a neutral. If either of these is true, then the transformer is absolutely mandatory.

There are commercial power supplies that would be suitable but would be expensive. See for example: **http://www.unitronlp.com/labprodtestpwrsupp.htm**

below 11.5V, say. I've examined the circuit in detail and read all the articles but there appears to be no mention of this important feature.

Without such a cut-out, lights operating unattended (eg, garden lighting) could exhaust the battery after a few winter days of poor sunlight and ruin the battery. The PIC would be quite capable of monitoring the battery voltage during the night and, if it gets too low, saving the battery by cutting off the drive to the switching Mosfet.

My second question refers to fitting a larger panel and battery to the controller to improve the performance and increase the lighting capacity. I estimate the controller should be able to cope with at least a 20W panel and two 12V 7Ah SLA batteries without causing problems for the circuitry, except perhaps for the MPPT charge controller.

Such an upgrade would result in a far better project overall by greatly increasing the range of applications. I would be interested in your reply. (B. T., Churchill, Vic).

- There is a low battery switch-off for the lamp at 11V, measured when under lamp load. This is mentioned on the first page of the article at the end of the section entitled "Types of Lighting" and it is in the specifications panel.

The main restriction when it comes to using a 20W panel is that the heatsinking for Q1 may need to be improved. The 470µF 35V low-ESR capacitors should also be replaced with either two 470µF 35V low-ESR capacitors in parallel or by a 1000µF 25V low-ESR capacitor.

Sources for switched capacitor filter ICs

Reader response 1: In the April 2012 issue, there was a query in the "Ask Silicon Chip" section about obtaining a MF4CN-50 switched capacitor filter IC, which you noted was obsolete. I want to point out that these chips are available on eBay from a US supplier for $4.00 + postage. (G. M., via email).

Reader response 2: I was reading a letter from R.W. about sourcing a switched capacitor filter (MF4CN-50) in the April edition and a possible source may be from eBay.

A quick search yielded a supplier in the USA. This specific seller has 100% positive feedback with a feedback score of 9123 and has 50 parts in stock costing $A3.88 per item and $A3.39 shipping (+10c for every additional item). I find eBay to be a great source of components and I have never been disappointed. (A. H., via email).

Erratic behaviour from light box

I recently constructed the Light Box Control Timer unit described in the November 2007 issue. The unit is intended to update the old 1980's vintage 555-based process timer on my existing UV light-box that consists of two Phillips TL-D 18W BLB black-light/blue fluoro tubes wired in series with a 40W ballast and 22W starters etc. All the internals of the light-box

continued on page 104

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Ask Silicon Chip

. . . continued from p100

are new, having been replaced within the past few months.

The Light Box Control Timer unit was a faithful replication of that described in Silicon Chip and when completed performed exactly as described in the article when operated on the bench with no load attached to the relay. However, when installed in the light-box with a fluorescent tube load connected, it began to behave somewhat erratically on start-up. Most of the time it would only generate a mere flicker from the tubes and then nothing. Pressing start again usually had the same outcome, although once in about five times, before the microprocessor became completely confused and displayed random outputs, the lamps would fire and run for their timed period before switching off.

Trying to improve the reliability of the start-up has proven frustrating and I have double-checked, tested and virtually rebuilt the controller board in several different configurations to try to isolate and remove the problem, including re-programming the microprocessor. The differing configurations included alternative relays (on and off the PCB), separate input mains power supplies, full suppression of the mains input supply etc.

After extended deliberations, I have concluded after testing the relay with both DC loads and other AC loads that the trigger action of the fluorescent starters seems somehow to be applying a power spike into the input circuitry of the 16F84A, shutting down operation almost immediately after it begins, suggesting that some further decoupling of the micro inputs may well be in order. I would be grateful if you could provide me with your thoughts and any possible solutions. (W. G., Dunedin, NZ).

- The inputs to the PIC are only held high via internal pull-up resistors and these may be too high for an application within a fluorescent tube lighting box. The problem should be solved by adding 10kΩ pull-up resistors between the +5V supply and the RB6 & RB7 inputs. Adding 100nF ceramic capacitors between these inputs and the pin 5 ground supply should shunt any interference to prevent false triggering (see also the errata in March 2012).

If this doesn't cure the problem, the timing board should be shielded from the fluorescent tubes, starters and ballast with an earthed piece of tinplate. SC

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Notes & Errata

Mix-it! 4-Channel Mixer, June 2012: Fig.8 on page 67 should show the top switch connecting to signal ground and the bottom switch going to pin 7 of IC1b (not the other way around).

Soft Starter for Power Tools, July 2012: the X2 capacitor specified in the parts list is a tight fit on the PCB. Element14 part code 1215460 is a better fit, as is the Altronics R3129.

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- Sizes: 1.5-6.3, 6.3-8.3, 8.3-10.4, 10.4-12.4, 12.4-16.5, 16.5-20.5mm

$69 (D1061)

THREAD REPAIR KIT
- Metric (M5x0.8mm, M6x1.0mm, M8x1.25mm, M10x1.5mm, M12x1.75mm)
- 130 pieces set

$149 (T100)

STEEL RULES
- Metric one side / Imperial on the other side

150mm/6" $6 (Q620)

300mm/12" $13 (Q621)

600mm/24" $19 (Q622)

CENTRE PUNCHES
- 2.5, 5.5, 7.0mm
- 150mm length

$19 (P367)

9" DRILL PRESS LOCKING CLAMP
- Fastens to drill press slot
- Secures workpieces tightly
- Maximum jaw opening 2"
- Throat depth 3"

NEW RELEASE

$18 (C103)

FEELER GAUGE
- 0.03-1.0mm thickness range
- High grade tool steel
- Hardened tempered & polished

$16 (Q616)

BS-4A BAND SAW
- 150 x 100mm capacity (W x H)
- 1/2hp 240V motor
- Vertical cutting table
- 3 speed

$329 (B002)

LED TORCH SET
- 1 x Aluminium flash light with 6 x LEDS
- 1 x LED flash light with flexible tube
- Includes 6 x AAA batteries

$16.50 (T950)

4 PIECE MAGNETIC PICK UP TOOL & INSPECTION MIRROR SET
- Mirror extends 240-920mm
- Magnet tool extends 65-695mm
- Fixed & swivel magnets can carry 3.6kgs
- Fixed magnet can carry 2.3kgs

$18 (M0009)

POCKET SCRIBER
- 150mm

$17 (Q631)

TOOLING CABINET WORKSTATION
- 100kg capacity per drawer
- Key lockable drawers & cupboard
- 950mm work bench height
- 1170 x 580 x 1450mm (W x D x H)

$950 (T773)

FLUROESCENT LIGHT WITH MAGNIFIER
- Designed with magnifier lens
- 22 Watts, 240V
- Long arm permits the light to reach a large area

$139 (L282)

HOLE SAW SETS
- Bi-Metal high speed steel hole saw set, supplied in convenient blow mould case
- Includes 3/8" & 1/2" shank arbors
- Pilot drill & spring

Plumbers Set 19,22,25,38,44,57mm $45 (D103)

Electricians Set 22,29,35,44,64mm $45 (D104)

COLD CHISEL SET
- Flat cold chisels
- Hi-grade chrome vanadium steel
- (Width x shaft hex x length)
  9.9 x 8.0 x 138mm
  12.6 x 11.0 x 150mm
  16.2 x 12 x 165mm

$15 (P363)

MAGNETIC BASE HAND TAP
- Quick release tapping chuck
- Magnetic base with on/off switch
- Guide bar provides precise tapping
- M3 - M12 capacity

$159 (T0119)

FREE 200mm SECOND CUT ENGINEERS FILE SET Valued at $31.90 (F100)

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